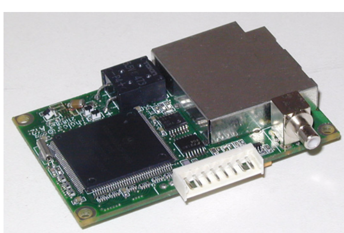
A12™ GPS OEM Board & Sensor

Reference Manual

A12 Sensor



A12 Board

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Acronyms Used In This Manual

2-D	Two-dimensional
3-D	Three-dimensional
ACK	Acknowledge
ASCII	American Standard Code for Information Interchange
BIT	Built-in Test
C/A	Coarse/Acquisition
CEP	Circular Error of Probability
CMOS	Complementary Metal-Oxide Semiconductor
COG	Course Over Ground
DB-9	Type of connector
DGPS	Differential GPS
E	East
EGNOS	European Geostationary Navigation Overlay System
ESD	Electrostatic Discharge
GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision
I/O	Input/Output
ID	Identification
L/C	Inductance/Capacitance
LNA	Low-Noise Amplifier
M	Meter
MSAS	Japanese Multi-function Transport System
MTCR	Missile Technology Control Regime
N	North
NAK	Not acknowledged
NMEA	National Marine Electronics Association
OEM	Original Equipment Manufacturer
P/N	Part Number
PC	Personal Computer
PDOP	Position Dilution of Precision
PPS	Pulse Per Second
PRN	Pseudo-random Number
RF	Radio Frequency
RHCP	Right-Hand Circular Polarization
RTCM	Radio Technical Commission for Maritime Services
S	South
S/A	Selective Availability
SBAS	Satellite-Based Augmentation System
SMA	Type of connector
SMB	Type of connector
SMT	Type of connector
SNR	Signal-to-Noise Ratio
SOG	Speed Over Ground
SPS	Standard Positioning Service
SV	Space Vehicle (Satellite)
TDOP	Time Dilution of Precision
TTFF	Time To First Fix
TTL	Transistor-Transistor Logic
UTC	Universal Time Coordinated
VDC	Volts Direct Current
VDOP	Vertical Dilution of Precision
W	West
WAAS	Wide Area Augmentation System
WGS	World Geodetic System

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General Information

Overview

This chapter presents a functional and hardware description of the A12 GPS OEM board, defines the RF interface and the power/input/output signal parameters, and lists power requirements and environmental specifications.

An A12 Evaluation and Development Kit, available separately, lets you rapidly set up and operate the A12 to determine suitability for your application. The kit offers:

- An A12 GPS OEM board enclosed in a housing with RS-232 interfaces,
- Easy-to-use connectors,
- A power switch.

The kit can also be used for software development (experimenting with commands, etc.) and for troubleshooting once the system is deployed. If you have purchased an A12 Evaluation and Development Kit and want to begin working with your kit immediately, go directly to Chapter 4 for initial setup instructions.

For the information of customers who have previously purchased or used an Ashtech G8, the A12 has addditional capability and is backward-compatible with the G8 except for a different RF connector.

Functional Description

The A12 OEM board, Figure 1.1, fulfills the need for a low-cost, high-performance GPS sensor, particularly where the requirements are for reliable positioning reporting in difficult environments such as vehicle navigation, fleet management, and personal asset management (tracking of cars, boats, people, etc.). The A12 is designed for system integration, offering autonomous or DGPS positioning, low power, small size, and the standard NMEA protocol. The A12 utilizes any voltage between 3.3 and 5 VDC, and supports two TTL-compatible serial communication ports that are accessible through the I/O connector.

The A12 OEM board processes signals from the Global Positioning System (GPS) satellite constellation and Satellite-Based Augmentation System (SBAS) satellites to provide real-time position, velocity, and time measurements. The A12 uses ten separate and parallel channels for Coarse/Acquisition (C/A) code-phase (a.k.a. pseudo-range) on the L1 (1575.42 MHz) band, and two channels to receive signals from the SBAS satellites. The A12 can also be configured to track GPS satellites on all 12 channels. The A12 receives satellite signals via an L-band antenna with integral low-noise amplifier (an active antenna must be supplied separately). The A12 board is capable of using a passive antenna provided the RF cable length is less than 6 inches. The A12 outputs position, speed, and time information, either autonomously or differentially corrected using DGPS corrections in RTCM SC-104 Version 2.2 format or using corrections from SBAS signals.

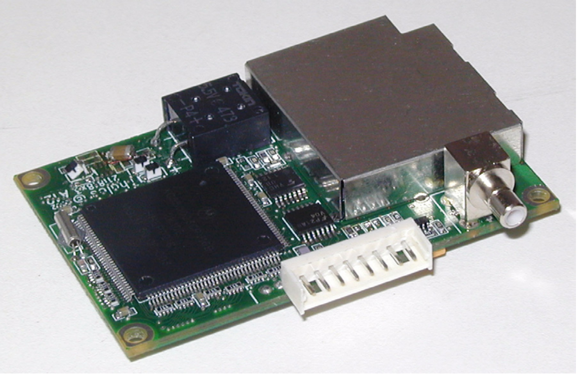

Figure 1.1: A12 OEM Board

Technical Specifications

Table 1.1 lists the more important technical specifications.

Table 1.1 Technical Specifications

Item	Specification
General	12-channel continuous tracking OEM GPS receiver board
GPS parameters	L1 frequency, C/A code (SPS)
Update rate	1 Hz
Communication interface	NMEA 0183 V3.0 using standard Ashtech command set
Message types	RTCM V2.2 differential remote message types 1, 3, 9
Serial ports	One TTL full duplex for primary I/O One TTL half duplex for RTCM
Baud rate	Software selectable 1200 bps to 115,200 bps. Maximum recommended character rate is 400 characters per second.

Table 1.1 Technical Specifications (continued)

Item	Specification
Size	Bare board: 1.54 x 2.36 x 0.41 inches (39 x 60 x 10 mm) With mechanical shield case: 1.58 x 2.41 x 0.52 in (40 x 61 x 13 mm)
Weight	Board: 0.7 oz. (20 gr) With mechanical shield case: 1.6 oz. (45.4 gr)
I/O interface	TTL compatible
Input voltage/ current consumption	3.3 to 5 VDC/55 to 70 mA typical
Backup power	2.7 to 3.6 VDC (6 µA)
Receiver noise figure	<7 dB typical without antenna

Performance Specifications

Table 1.2 summarizes the more important performance specifications. Additional details are presented in Table 6.1 on page 94.

Table 1.2 Performance Specifications

Item	Specification
Real-time position accuracy	Horizontal CEP / Horizontal 95% Autonomous: 3.0m / 5.0m SBAS: 1.0m / 3.0m DGPS (local): 0.8m / 1.5m
Typical acquisition time **(Refer to note below)**	<10 sec hot start <45 sec warm start <150 sec cold start
Typical reacquisition time	1 sec from total satellite blockage for less than 20 seconds 3-5 sec from total satellite blockage for less than 180 seconds
Update rate	User-selectable from 1 second to 99 seconds in 1-second increments synchronized with GPS.
1 PPS output	A12 calculates time and outputs the first 1 PPS pulse only after it has an initial position fix. 1 PPS pulse output is synchronized to GPS time ± 1 msec. The A12 continues to output 1 PPS during position outages, but with reduced accuracy.
Geoid model	Supported internally
Magnetic variation model	Supported internally

If the A12 has a valid almanac and ephemeris, but has retained a last known position more than 1000 km from its actual location, the receiver should be reset using the $PASHS,INI command to minimize start time. If not reset, this condition may cause a long delay in the start time of the receiver.

Hardware Description

Physical Configuration

The A12 is delivered with a mechanical shield case. This mechanical shield case provides protection while handling, a significant degree of ESD protection, and a small degree of EMI protection. We recommended you use the A12 with the mechanical shield case, but this is not absolutely necessary. When the board is used within the mechanical shield case, the most common mounting method utilizes the three mounting holes on the bottom of the mechanical shield case, as shown in Figure 1.2 .

CAUTION
When choosing screws for mounting the mechanical shield case, the screw length should be chosen so as to insert no more than 1/8 inch beyond the outer surface of the shield case. A longer screw may damage the OEM board and cause unreliable operation.

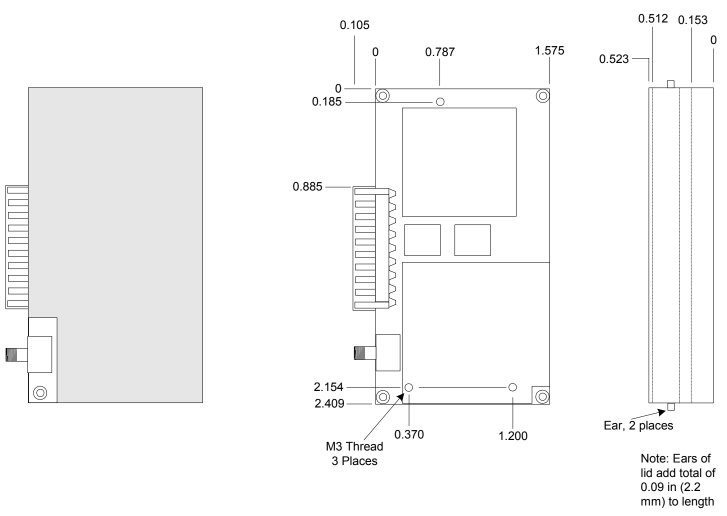

Figure 1.2: Mechanical Shield Case Configuration

When used outside the mechanical shield case, the A12 board can be mounted using the mounting holes provided in each corner as shown in Figure 1.3. A separate RF shield is soldered to the board, located as shown in Figure 1.3. The RF shield must always remain on the board.

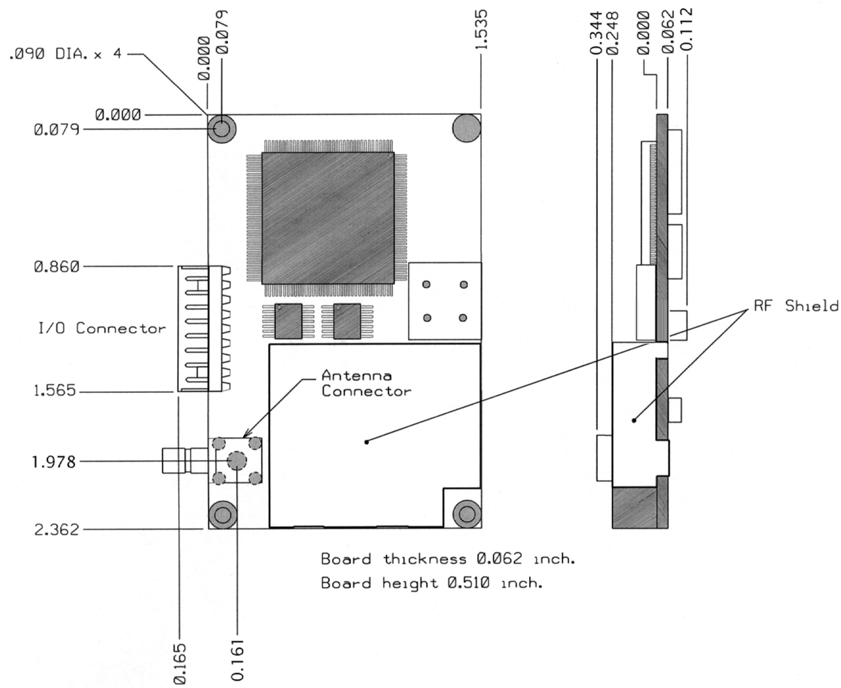

Figure 1.3: Bare Board Configuration

Table 1.3 Dimensions

Characteristic	Without Mechanical Shield Case		With Mechanical Shield Case	
	Inches	**Millimeters**	**Inches**	**Millimeters**
Length	2.362	60.0	2.410	61.2
Width	1.535	39.0	1.575	40
Thickness	0.41	10.4	0.523	13.3
Weight	0.7 oz.	19.8 gr	1.6 oz.	45.4 gr
Mounting Method	One hole in each corner of board	One hole in each corner of board	Three holes on bottom of shield case	Three holes on bottom of shield case
Mounting hole diameter	Figure 1.3	Figure 1.3	Figure 1.2	Figure 1.2
Mounting hole location	Figure 1.3	Figure 1.3	Figure 1.2	Figure 1.2

Power/Input/Output Connections

Table 1.4 lists the power/input/output connections for the Molex 8-pin I/O connector. Connector types are defined in Chapter 2.

Table 1.4 Power/Input/Output Connections

Pin	Signal Designation	Function
1	VCC	Primary board power connection
2	V_ANT	Antenna power connection
3	V_BACK	Battery backup power connection
4	GND	Ground
5	RTCM	Receive Port B: Receive data at A12 from external device
6	RXD	Receive Port A: Receive data at A12 from external device
7	TXD	Transmit Port A: Transmit data from A12 to external device
8	1 PPS	1 PPS output

Interfaces to External Equipment

All Ashtech GPS receivers use a combination of standard NMEA commands and Ashtech NMEA style commands ("PASH" commands).

The A12 returns responses in standard NMEA format or Ashtech NMEA style format, depending upon the command given the receiver. The standard NMEA responses are $GPALM, $GPGGA, $GPGLL, $GPGSA, $GPGSV, $GPRMC, $GPVTG, and $GPZDA per NMEA specification 0183 V3.0. In addition, Ashtech has implemented a set of NMEA style messages that are maintained for compatibility with the Ashtech OEM product line. These responses are prefixed with the string $PASHR. All responses include a checksum.

NMEA responses and $PASH commands and responses are described in detail in Chapter 5.

Power Requirements

The A12 requires the following operating power (typical):

Main power: 3.3 to 5.0 VDC

Nominal current: 55 to 70 mA

Nominal power: 230 mW @ 3.3 VDC

Backup power: 6 µA at 2.7 to 3.6 VDC

Antenna power (V_ANT): 5 VDC, 300 mA max (active antenna must be supplied separately)

Environmental Limitations

The A12 operates within the environmental limitations listed in Table 1.5.

Table 1.5 Environmental Limitations

Condition	Specification
Operating temperature	-30°C to +80°C
Storage temperature	-40°C to +85°C
Humidity	95% RH non-condensing @ +60°C

Table 1.5 Environmental Limitations (continued)

Condition	Specification	
Vibration	0.008 g^2/Hz 0.05 g^2/Hz 3 dB/octave	5 to 20 Hz 20 to 100 Hz 100 to 900 Hz
Speed limitations	1000 knots (514 m/sec)*	
Altitude limitations	60,000 feet (18,288 m)*	
* The A12 produces no valid position information beyond these limits.		

Antenna

For optimum performance, the A12 requires a reliable, low-power antenna with a built-in low-noise amplifier (LNA). Many antenna manufacturers provide low-cost antennas optimized for a mobile environment, with many choices of design, filtering options, LNA gain level, packaging, connector style, cable length, and mounting options. Given the wide variety of choices in the marketplace, we recommend you obtain your antenna directly from the manufacturer. Table 1.6 lists the required antenna electrical performance specifications. Contact your local distributor for a list of recommended antenna sources.

Table 1.6 Antenna Specifications

Parameter	Specification
Center frequency	1575.42 MHz
Output impedance	50 ohms
Polarization:	RHCP
Gain	Recommended 1 to 2 dBic at zenith
LNA gain	LNA gain - cable loss >10dB
Filter	30 dB attenuation 100 MHz above or below center frequency
Noise figure	< 2.5 dB
Power input	Antenna is powered via V_ANT at pin 2. User supplies power for antenna. Voltage input should be limited to 5 VDC or less.

The A12 contains an antenna supply circuit that utilizes an L/C filter to isolate the DC power from the GPS RF energy. This circuit supplies power to the antenna via the center pin of the RF connector. The maximum current allowance through the V_ANT pin is 300 mA.

A diagram of the antenna supply circuit is shown in Figure 1.4. There is no short-circuit protection for the external power supply applying voltage to the V_{ant} line.

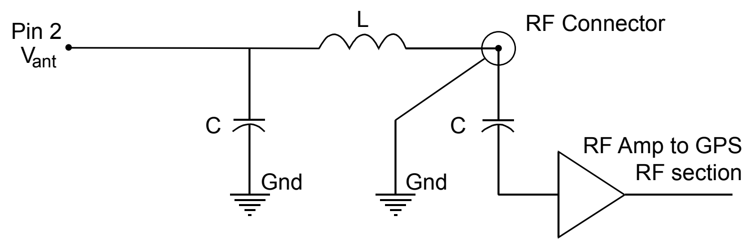

Figure 1.4: Antenna Supply Circuit

There is no impedance requirement at pin 2 (V_ANT). Pin 2 is usually driven by a low-impedance power supply. RF decoupling is done on the A12 board.

Radio Interference

Some radio transmitters, cellular phones, or other mobile communications equipment can interfere with the operation of GPS receivers. Ashtech recommends that you verify that nearby hand-held or mobile communications devices do not interfere with GPS receivers before setting up your project.

The A12 is equipped with an RF shield over the RF section of the receiver. This protects the sensitive components in this area of the board, and also eliminates emissions from this section. The RF shield is soldered to the board and must remain in place at all times. The mechanical shield case does provide a small degree of additional RF isolation. It is recommended that the mechanical shield case be used, but the A12 operates reliably without the mechanical shield case.

Getting Started

General

This section defines the procedures to get your A12 GPS OEM board operating as quickly as possible:

- Procedure for connecting the A12 to power, the antenna, and your equipment or system electronics
- Important communication parameters
- Instructions for establishing communications with the A12 using typical communications software with an IBM-compatible PC
- Procedure for sending common commands to the A12

Quick Start

If you have the A12 Evaluation and Development Kit, use it for quick setup and evaluation. Go directly to Chapter 4 for instructions. If you do not have the A12 Evaluation and Development Kit, proceed with the following instructions.

Connection Procedures

Board

Figure 2.1 shows the power and I/O connections to the 8-pin I/O connector on the board.

CAUTION
To avoid damage to the A12, always turn off the power supply before connecting or disconnecting to the 8-pin I/O connector.

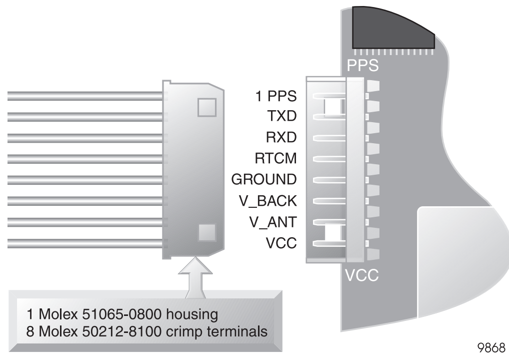

Figure 2.1: Power and I/O Connections for Bare OEM Board

1. To interface to the board, you will need to connect to two different interface connectors:
   - **I/O connector** - the I/O connector on the A12 OEM board is a Molex socket P/N 53254-0810. To mate with this socket, you will need to provide a board-based connector or construct a power-I/O cable. A cable requires a Molex terminal crimp housing P/N 51065-0800 and eight crimp pins P/N 50212-8100. Assemble a power-I/O cable using these parts, as shown in Figure 2.1.

There may be other mating connector options that are more appropriate for your application. Contact your supplier for additional mating connector information.

   - **RF connector** - The RF connector is a right-angled SMB connector.
2. Once you have constructed a board-based connector or a power-I/O cable, connect the female plug on the cable to the 8-pin Molex I/O connector on the A12.
3. Connect the wires of the power-I/O cable as specified in Table 2.1. Do not turn on power at this time; proceed with other connections as specified below.

Table 2.1 Power/Input/Output Parameters

Pin	Signal Designation	Function
1	VCC	Primary board power connection
2	V_ANT	Antenna power connection
3	V_BACK	Battery backup power connection
4	GND	Ground
5	RTCM	Receive Port B: Receive data at A12 from external device
6	RXD	Receive Port A: Receive data at A12 from external device
7	TXD	Transmit Port A: Transmit data from A12 to external device
8	1 PPS	1 PPS event marker output TTL

4. Once you have constructed the antenna interface cable, connect the antenna cable to the Hirose antenna connector on the A12 and connect your antenna.

For maximum reliability, connection and disconnection of the Hirose antenna connector should be minimized.

The A12 is designed to work with an antenna that includes an LNA. The antenna is powered via V_ANT and is isolated from DC ground. The gain of the antenna-preamplifier minus the loss of the cable should be between 10 and 35 dB.

Best results are obtained if the antenna has an unobstructed view of the entire sky. A ground plane is desirable but not necessary. Should you want the antenna stationary, try to locate it as high as possible and away from metallic objects such as towers, and large structures such as buildings. These objects may reflect the incoming GPS signals, causing multipath reflections that can reduce accuracy.

5. With all connections made as described above, apply 3.3 or 5 VDC power to the A12 at pin 1 (VCC). Remember also to be sure power is applied to the antenna via pin 2 (V_ANT). Antenna power restrictions are defined in Chapter 1.

CAUTION
The A12 uses 5 VDC power, not 12 VDC. Connect the appropriate power input line (VCC) to a stable 5-volt source ONLY. The voltage can fluctuate no more than ± 5%.

When the A12 is connected to power, it automatically begins its startup and acquisition routines, attempting to acquire satellites (SVs or Space Vehicles) within the field of view of the antenna.

To ensure the fastest possible restart times, you should also connect the A12 to a power backup source at pin 3 (V_BACK). Your backup source should be in the range of 2.7 to 3.6 VDC. Backup draws approximately 6 µA, depending upon the backup voltage.

Serial Data Communication

Communication Port Setup

After performing the steps above, you are ready to command the A12 and receive data. The A12 serial port A must be connected to a PC, microprocessor, or other intelligent processing device, before you can issue commands. The A12 OEM board utilizes CMOS signal levels (+ 3.3 VDC, 0 VDC) for communication, not RS-232 levels (± 12 VDC). The A12 is also compatible with external TTL-level signals and will accept 5V signals on the receive port. If you plan to communicate directly with the A12 OEM board from a PC, you must first convert the PC RS-232 interface levels to TTL levels. Specific I/O interface levels are provided in Table 2.2.

CAUTION
Attempting to communicate to the A12 OEM board using RS-232 voltage levels will result in poor operation or failure in communication. Applying a negative voltage to the I/O pins could cause excessive current draw or damage to the A12.

Table 2.2 TTL I/O Interface Levels

Voltage	Minimum	Maximum
V_{il}	-0.5V	0.8V
V_{ih}	2.2 V	Vcc + 0.5V
V_{ol}	---	0.4V
V_{oh}	2.4V	---

Table 2.3 lists the default communication parameters of the A12 at first power-up.

Table 2.3 Default A12 Communication Parameters

Baud	Data Bits	Parity	Stop Bits	Port
4800	8	None	One	A

When first establishing communication with the A12, the communications interface must use these parameters, otherwise the A12 will not recognize any serial input. Once communication is established at 4800 baud, the A12 can be reconfigured to operate at a different baud rate by issuing $PASHS commands to the serial port from the attached PC or other processing device.

RTS/CTS Considerations

Once you convert the A12 GPS OEM board TTL outputs to RS-232 levels, there is one other important consideration.

The RS-232 specification is very general, intended to cover a wide variety of computer-to-computer communication situations. As such, it contains a lot of controls that are not necessary in most situations. For the A12 OEM board, merely connecting GND to GND, TX1 to RX2, and TX2 to RX1 is all that is required. However, some computer software uses RTS (Request To Send) and CTS (Clear To Send); this is known as flow control. The purpose of these signals is to allow the intended receiver to hold off transmission until it is able to take care of the data. The transmitter will assert RTS and then wait until it sees CTS before beginning transmission. This avoids loss of data that could occur if the transmitter started before the receiver was ready. The A12 OEM board does not utilize flow control and therefore ignores RTS/CTS signals on the RS-232 line.

Most system integrators simply connect RTS to CTS at both ends of the communication channel. In this case, as soon as the transmitter asserts RTS, it sees CTS and begins transmission. Because the A12 OEM board does not utilize flow control, you may need to connect RTS to CTS at the computer or processor that is communicating with the A12. This is an individual judgement call which depends upon both the hardware configuration of the host and on the design of the software in the host. It may or may not be necessary, but should be considered in your interface design. The A12 Evaluator (see Chapter 4) connects the RTS and CTS lines; the A12 OEM board does not.

Data Output

Even though the A12 may be calculating positions, it does not output any data until you send a message commanding it to do so.

Initial Operating Instructions

After the A12 is powered and running, you may send it command messages in order to change the output or modify operating parameters. The following procedure describes briefly how to send commands to and receive information from the A12 using an IBM-compatible PC. Many standard communications software packages allow you to interface with the A12. Be sure to send commands to Port A of the A12 receiver.

Your command can be typed in upper or lower case, and must be completed by pressing the **<**enter**>** key. If you have typed and sent the command correctly, you should get an ACK response for a correct command, and a NAK response for an illegal or incorrect command. To become familiar with the A12 messages, send a few common commands to the A12 and observe the responses.

1. Type: $PASHQ,PRT and press **<**enter**>**. This command queries the communication setup of the port.

Pressing <enter> is equivalent to <CR><LF>.

2. The response message is:

   $PASHR,PRT,A,4

   This message indicates port A of the A12 is using its default communications setup 4, which is 4800 baud, eight data bits, no parity, and one stop bit. For details on this and other commands and responses, refer to Chapter 5.

3

Operation

This section summarizes system setup, operation at power-up, input and output messages, serial port configuration, parameter settings and status, the satellite search algorithm, modes of operation, antenna position setting, NMEA outputs, and differential operation.

System Setup

Verify that the A12 is set up as described in Chapter 2.

Message Format

The A12 command/response firmware allocates the two RS-232 ports (A and B) to receive command messages from an external control device (such as a PC), and receive differential corrections from a reference station. Commands can be input to either port A or B, but only port A provides responses to commands.

Input Messages

The input messages comprise **set** command messages, and **query** command messages. The **set** commands instruct the A12 to perform a specified and often continuous activity; the **query** commands instruct the A12 to report its present status one time only. The general command messages comply with the NMEA 0183 standard to the following extent:

- NMEA 0183 ASCII strings following $ character
- Headers are Ashtech NMEA style, registered with NMEA (i.e., PASH)
- Message IDs are Ashtech NMEA style
- Data items are separated by commas
- Checksum character delimiter and NMEA checksum bytes are recognized by the A12 but are optional. The hexadecimal checksum is

computed by exclusive OR-ing all of the bytes in the message between, but not including, the $ and the *.

- Message is ended with the standard NMEA message terminator characters, <CR> and <LF> (same as **<**enter**>**).ll command messages (set, query or general) recognize upper or lower case letters. They are accepted by **<**enter**>.** A valid set command causes the A12 to return the **$PASHR,ACK*3D, "acknowledged"** response message. A set command containing a valid $PASHS set command header followed by character combinations unrecognized by the A12 causes return of the **$PASHR,NAK*30, "not-acknowledged"** response message. All other invalid set commands are ignored. Valid query and general command messages are acknowledged by return of the requested information, and all invalid query and general commands cause the A12 to return the **$PASHR,NAK*30 "**not acknowledged**"** response message.

Output Messages

Output messages are messages the A12 sends to the PC or system electronics in response to a command message. These messages comprise general status messages, command acknowledged/not acknowledged messages, and GPS data messages. The general status messages have free-form Ashtech NMEA style formats. The command acknowledged/not acknowledged messages and GPS data messages comply with NMEA 0183 as follows:

- NMEA ASCII strings following $-character
- Headers are standard NMEA or Ashtech NMEA style
- Message IDs are standard NMEA or Ashtech NMEA style
- Standard NMEA format messages contain hexadecimal checksum bytes
- Data items are separated by commas; successive commas indicate invalid or missing data (null fields)
- Message is ended with <CR><LF>, the standard NMEA message terminator characters

Serial Port Configuration

Port A provides two-way full duplex RS-232 communication. Be aware that the signals are, however, at TTL levels. The default transmit/receive protocol is 4800 baud, eight data bits, no parity, and one stop bit (8N1). The baud rate is adjustable using the **$PASHS,SPD** speed set command; the data bit, stop bit and parity protocol are always 8N1.

On initial power-up or after issuing the **$PASHS,RST** (reset to defaults) command, the default is 4800 baud for both RS-232 serial ports A and B.

The baud rates between the A12 and the interfacing equipment must be the same for both the port and the device connected to that port.

To maintain communication with the A12 while changing the baud rate, issue the **$PASHS,SPD** (set command) to change the A12 baud rate, then change the baud rate of the command device to match the new A12 rate.

Antenna Connection

The A12 requires that a compatible active antenna be connected to the antenna port for reliable operation. Antenna specifications are provided in Chapter 1. The antenna must have a clear view of the entire sky in order for the A12 to meet the specifications defined in this manual.

Satellite Search Algorithm

When the A12 is operated for the first time after receipt from Ashtech, or after the power and back-up battery have been disconnected, no almanac or ephemeris data are available. The A12 always assigns the first 12 elements of a 32-element table of SV PRN numbers to its 12 channels. Within 35 to 40 seconds after locking the first SV, the A12 time is set. The A12 computes its first position after three (for 2D) or four (for 3D) SVs are locked, provided that the satellite geometry is adequate. The A12 continuously stores the most recent almanac, ephemeris, and position data into its battery-backed memory, which allows for faster position computation when next turned on.

The A12 performs a cold start if there are no valid almanac or ephemeris data in the battery-backed memory, or if it has no previously known position; this is generally true if the A12 has been off for more than six months. With no SV information to help narrow the search, cold start typically requires about two minutes to compute the initial position. If the A12 has been off for less than six months but more than four to six hours, then the stored almanac and position data allow it to narrow the SV search and perform a warm start. In warm start the initial position is typically computed in about 45 seconds. The A12 will turn on with a hot start if its battery-backed memory contains valid almanac, ephemeris, and position data; this is generally true if the A12 has been off for no more than two hours. This data allows the A12 to search only for visible SVs in known locations, and the first position is typically computed in about 10 seconds.

If the A12 has a valid almanac and ephemeris, but has retained a last known position more than 1000 km from its actual location, the receiver should be reset using the $PASHS,INI command to minimize start time. If not reset, this condition may cause a long delay in the start time of the receiver.

Parameter Settings and Status

Table 3.1 lists the default operational parameters. These parameters can be changed using the indicated set commands; detailed explanations of the set commands are presented in chapter 5. On initial power-up or after use of the **$PASHS,RST** (reset to default command), the A12 reverts to its default parameter settings. To list the current status of these settings, there is one query command available:

$PASHQ,PAR (general parameters)

The response message for the default values of the query command **$PASHQ,PAR** (general parameters) is in the format shown below:

```
PMD:4    FIX:0    PEM:05    PDP:06    HDP:04
DTM:W84   LTZ:+00,00      SAV:N
USE:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
CDS:  AUTO   DIF_RTCM_MODE:OFF    PRT:B     AUT:Y
MAX:0015
LAT:0000.000000,N LON:00000.000000,E      ALT:+00000.00
NMEA: ALM GGA GLL GSA GSV MSG POS RMC SAT  VTG ZDA
PRTA:   --- --- --- --- --- --- --- --- --- --- --- --- ---
PER:    001.0
SPD:    PORT A:5     PORT B:5
ANT: Y     WAAS: Y
```

CAUTION

The $PASHQ,PAR response message is free-form and subject to change in future firmware versions. These messages are not intended to be computer-readable.

Table 3.1 Default Parameters

Item	Default Value	Set Command	Page
RECEIVER CONTROL COMMANDS			
Latitude	None	$PASHS,POS	51
Longitude	None	$PASHS,POS	51
Altitude	None	$PASHS,POS	51
Navigation position mode	4	$PASHS,PMD	51
2D altitude	0	$PASHS,ALT	45
HDOP mask	4	$PASHS,HDP	46
PDOP mask	6	$PASHS,PDP	50
Elevation mask	5 degrees above horizon	$PASHS,PEM	50
Datum	WGS-84	$PASHS,DTM	45
Satellites inhibited	none	$PASHS,USE	58
DGPS positioning	OFF	$PASHS,RTC	89
Auto differential mode	Enabled	$PASHS,RTC,AUT	89
Differential data age selection	15 seconds	$PASHS,RTC,MAX	89
Serial port A speed	4 (corresponds to 4800 bps)	$PASHS,SPD	55
Serial port B speed	4 (corresponds to 4800 bps)	$PASHS,SPD	55
Altitude position fix mode	0	$PASHS,FIX	46
Time zone offset	00:00	$PASHS,LTZ	48
Point positioning	N (disabled)	$PASHS,PPO	52
Save parameters	Y (save)	$PASHS,SAV	55
Initialize receiver & serial ports	4800 baud	$PASHS,INI	47
SBAS	Enabled and DGPS on	$PASHS,WAS	58
NMEA COMMANDS			
Enable ALM msg to port	A, OFF	$PASHS,NME,ALM	63
Enable GGA msg to port	A, OFF	$PASHS,NME,GGA	66
Enable GLL msg to port	A, OFF	$PASHS,NME,GLL	69
Enable GSA msg to port	A, OFF	$PASHS,NME,GSA	71
Enable GSV msg to port	A, OFF	$PASHS,NME,GSV	72
Enable RMC message to port	A, OFF	$PASHS,NME,RMC	78
Enable VTG msg to port	A, OFF	$PASHS,NME,VTG	83
Enable ZDA msg to port	A, OFF	$PASHS,NME,ZDA	85
Enable POS msg to port	A, OFF	$PASHS,NME,POS	75
Enable SAT msg to port	A, OFF	$PASHS,NME,SAT	80
Receiver update interval	1 second	$PASHS,NME,PER	74

Saving New Parameter Settings

If you want to save any parameters changed by a set command, parameter values can be saved by the **$PASHS,SAV,Y** set command. Once this command has been used, the A12 will use the saved parameters instead of the defaults as long as there is the appropriate battery backup voltage on pin 3 (V-back). Without battery backup, the parameters will **NOT** be saved. The command **$PASHS,RST** always reinstates the defaults.

Position Modes

The A12 operates in two position modes, 3D and 2D. These modes are explained in detail in “Position Modes” on page 92.

Altitude Hold Definition

Two modes are available to determine what altitude is selected when the A12 is in altitude-hold mode. The **$PASHS,FIX** set command can be used to select between these modes.

- In **mode 0**, the most recent altitude is used. This is either the one entered by using the **$PASHS,ALT** or **$PASHS,POS** set command or the one computed as part of a 3D position, whichever is most recent.
- In **mode 1**, only the last altitude entered by using the $PASHS,ALT set command is used in the position fix solution.

On initial power-up or after use of the **$PASHS,RST** default parameter reset command, the most recent antenna altitude is zero.

Antenna Position Setting

Two commands are available to enter the known antenna position:

$PASHS,POS (position setting including latitude, longitude, altitude)

$PASHS,ALT (altitude for fixed 2D operation)

NMEA Outputs

The A12 allows you to output messages in NMEA format, and other messages through serial port A, as listed in Table 3.2.

Table 3.2 NMEA and Miscellaneous Output Messages

Message	Type	Description	Page
$GPALM	NMEA	GPS almanac	63
$GPGGA	NMEA	Position fix	66
$GPGLL	NMEA	Geographic latitude/longitude	69
$GPGSA	NMEA	GPS DOP and active satellites	71
$GPGSV	NMEA	GPS satellites in view	73
$GPRMC	NMEA	Recommended minimum specific GPS Data	78
$GPVTG	NMEA	Course over ground and ground speed	83
$GPZDA	NMEA	Time and date	85
$PASHR,POS	Ashtech NMEA style	Position	75
$PASHR,SAT	Ashtech NMEA style	Satellite status	81

Any combination of these messages can be output through serial port A. The output rate is determined by the **$PASHS,NME,PER** command, and can be set to any value between 1 and 999 seconds. Additional details are presented in the discussion of NMEA message commands in Chapter 5, *Command/ Response Formats*.

All standard NMEA messages are a string of ASCII characters delimited by commas and that comply with the NMEA standard 0183, Version 3.0. All non-standard messages are a string of ASCII characters delimited by commas using the Ashtech NMEA style response format.

Differential Operation

This section discusses differential operation, sources of error, messages for differential operation, and RTCM 104 format as it applies to a remote station.

General

Real-time "Broadcast" differential GPS positioning (DGPS) involves a reference (base) station computing SV range corrections and transmitting them to a remote (rover) unit. The A12 is operates as a remote unit. When a reference station transmits these corrections in real time to the A12 via a communications link, the A12 applies the corrections to its measured ranges and uses the corrected ranges to compute its position.

The base receiver determines range corrections by subtracting the measured range from the true range, computed by using an accurate position entered in the receiver. This accurate position must have been previously surveyed using GPS or some other technique.

SBAS Operation

The A12 unit has two channels dedicated for tracking Satellite-Based Augmentation System (SBAS) satellites. You can configure the A12 receiver to track GPS satellites on all 12 channels by disabling WAAS reception using command $PASHS,WAS,OFF (refer to page 58). In the DGPS remote mode, the A12 automatically utilizes corrections from the SBAS (WAAS/EGNOS/MSAS) satellites to provide differentially corrected position. However, RTCM (local) corrections take priority over SBAS, i.e., if both corrections are available, RTCM corrections will be used. The A12 does not use the ranging information provided in the SBAS signals for position computation.

As a stand-alone receiver, and with SA (Selective Availability) on, the A12 typically computes a position within about 30 meters of truth but always within 100 meters. In differential mode, the A12 can achieve 1 m or better precision using local corrections, and 2-4 m accuracy utilizing SBAS (WAAS/EGNOS/MSAS) corrections. For local DGPS operation, a communication link must exist between the base and remote receivers. The communication link can be a radio link, telephone line, cellular phone, communications satellite link, or any other medium that can transfer digital data.

Sources of Error

The major sources of error affecting the accuracy of GPS range measurements are SA (Selective Availability), SV orbit estimation, SV clock estimation, ionosphere, troposphere, and receiver noise in measuring range. The first five sources of error are almost totally removed using differential GPS.

Receiver noise is not correlated between the base and the remote receiver and is not cancelled by differential GPS.

Total position error (or error-in-position) is a function of the range errors (or errors-in-range) multiplied by the PDOP (three-coordinate position dilution of precision). The PDOP is a function of the geometry of the SVs.

RTCM Messages

In DGPS mode the A12 accepts RTCM SC-104 Version 2.2 differential formats. The A12 is set to receive RTCM corrections in either of the two ports by issuing the set command **$PASHS,RTC,REM,c** where c is the port. Of RTCM message types 1 through 64, the A12 processes type 3 for station location, and types 1 and 9 for RTCM differential corrections. The differential corrections are automatically processed by the A12.

It is recommended, but not required, that RTCM information be input on port B.

RTCM message type 3 provides user information from the reference (base) station, while RTCM message types 1 and 9 provide differential correction information. The reference station sends types 1 and 9 continuously and may send type 3 periodically. The $PASHS,NME,MSG set command and $PASHQ,MSG query command cause the most recent RTCM input data to be reported, via the $GPMSG message (not implemented in initial release).

On initial power-up or after use of the **$PASHS,RST** (reset to defaults command) the A12 default automatic differential mode is OFF, and the default is 15 seconds for the maximum age of an RTCM differential correction, above which it is not be used. If the automatic mode is not enabled by the **$PASHS,RTC,AUT** set command and the differential correction data is older than the maximum age specified by the **$PASHS,RTC,MAX** set command, the A12 does not return antenna position data.

In automatic mode, if no differential correction data is received or the age of data is older than the specified maximum age, the A12 returns the uncorrected position or an SBAS DGPS position.

RTCM 104 Format, Version 2.2

The A12 uses six-of-eight format (data bits a1 through a6 of an eight-bit byte) for communication between the reference station and user equipment.

The A12 can accept any type of RTCM message, however it decodes types 1, 3, and 9, as detailed in Table 3.3, and uses only types 1 and 9 for differential corrections.

Table 3.3 RTCM Format

Message Type	Contents of message
1	Differential GPS corrections
3	Reference station parameters
9	High-rate differential GPS corrections

Pulse Generation (1 PPS)

The A12 calculates time and outputs the first 1 PPS pulse only after it has obtained an initial position fix. The A12 continues to output 1 PPS during position outages, but with reduced accuracy. Figure 3.1 shows the timing relationships. The 1 PPS output is accurate to ±1 msec if the receiver is within 300 meters of the last valid position. Time is reported in the NMEA message

ZDA. The 1 PPS output is available on pin 8 of the A12 8-pin I/O connector.

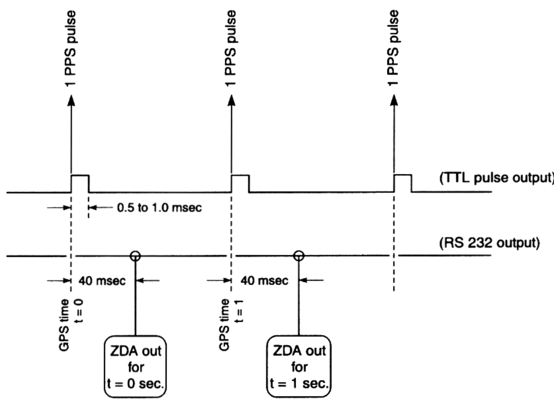

Figure 3.1: Relationship of GPS Time in PRN Record to 1 PPS Pulse

Figure 3.2 shows the 1 PPS pulse characteristics. The 1 PPS pulse occurs when the signal goes high. The 1 PPS is generated exactly on the GPS second, and the pulse remains high for 1millisecond.

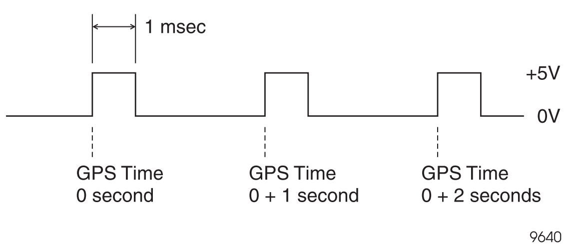

Figure 3.2: PPS Pulse

Magnetic Variation and Geoid Models

The A12 uses the WMM-2000 magnetic variation model. Details of this model can be obtained from the National Geophysical Data Center in Boulder, CO.

The A12 uses a proprietary geoidal height model with a resolution of 10 degrees latitude and longitude, using interpolation to obtain height at a particular location. Details can be obtained upon request from Ashtech Technical Support.

4

A12 Development Kit

Overview

The A12 Development Kit, Figure 4.1, lets you rapidly set up and operate the A12 to determine suitability for your application. The kit can also be used for software development (experimenting with commands, etc.) and for troubleshooting once your system is deployed.

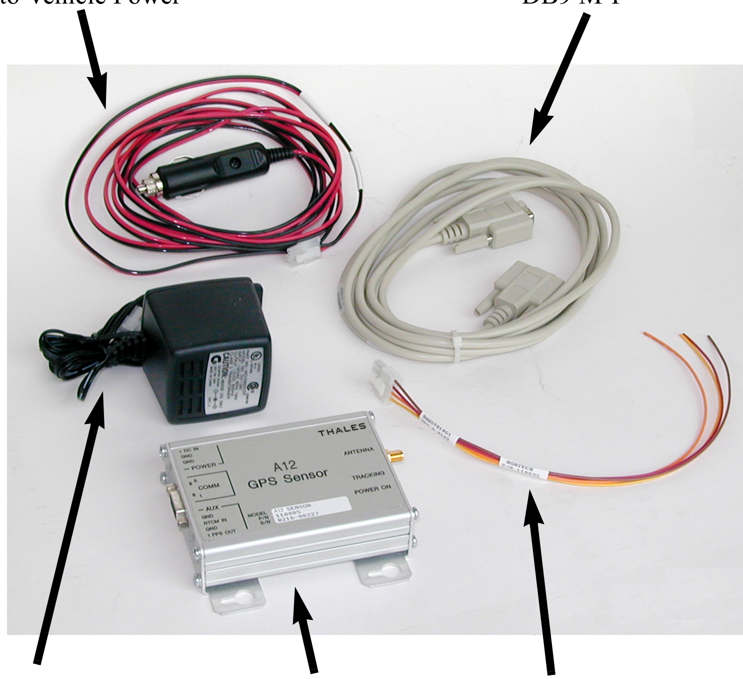

Figure 4.1: A12 Development Kit

The kit provides the following conveniences which you would otherwise have to devise yourself:

- Built-in RS-232 interface does TTL to RS-232 conversion
- Standard SMA antenna connector
- Standard serial interface connector connects directly to PC
- Packaged unit protects OEM board in rugged test and evaluation environments
- Connects to standard 12 VDC power (such as a vehicle battery)
- Built-in battery eliminates need for battery backup connection
- Wide range of input power provides flexibility in test setups
- All interface cabling

Mounting the A12 Sensor

The A12 Sensor can be mounted in any orientation. Mounting flanges are provided to accommodate the four #6 mounting screws. Keyhole-shaped holes on the mounting flanges allow installation and removal of the unit while leaving the screws in place. A full-size mounting template is supplied with each A12 Sensor. Table 4.1 lists dimensions of interest.

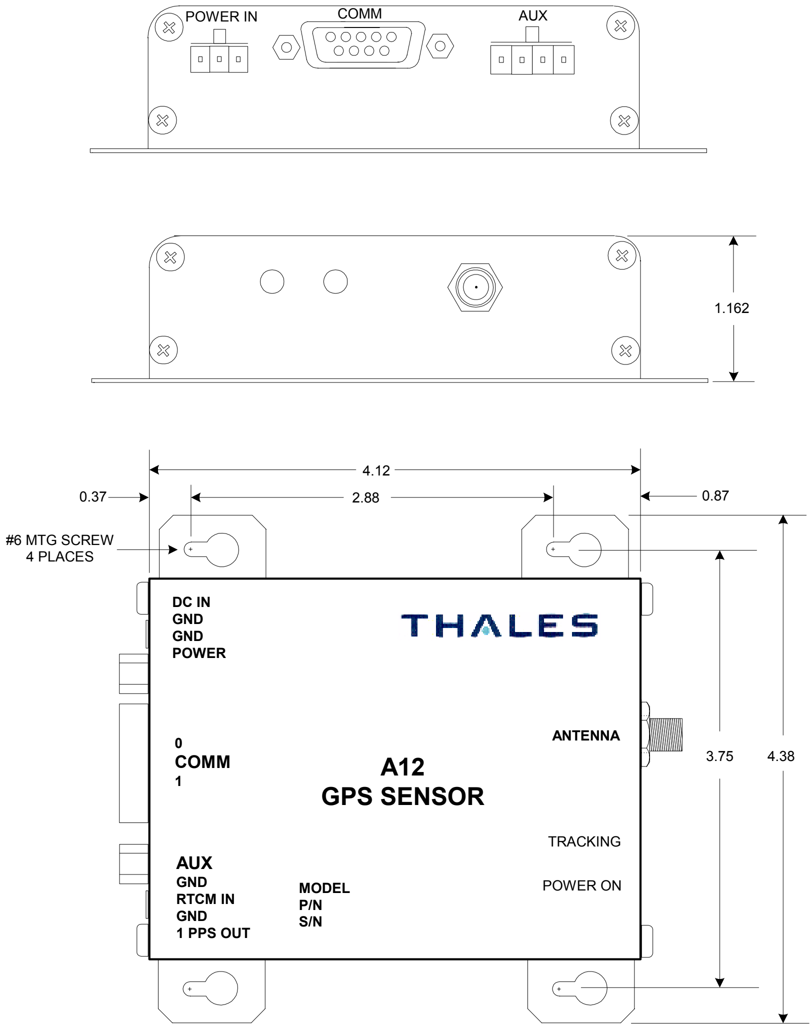

Figure 4.2: Mounting Dimensions (Inches)

A12 Development Kit

Table 4.1 A12 Sensor Dimensions

Characteristic	Description
Length	4.12 in (104.6 mm)
Width	4.38 in (111.2 mm)
Thickness	1.162 in (29.5 mm)
Weight	8.5 oz (240 g)
Mounting Method	Four #6 screws
Mounting hole diameter	0.125 in (3 mm)
Mounting hole location	Template supplied
Power	10 to 18 VDC, 12 VDC nominal Current 200 mA max using recommended antenna (Aromat VIC-1)

Configuring Your Kit for Operation

To configure and operate your A12 Evaluation and Development kit, follow the six steps below in sequence. For detailed mounting instructions and detailed cable connection information, refer to the appropriate sections later in this chapter.

Step 1 - Inventory Your Equipment

Check your A12 Development Kit to ensure that all items are available, as shown in Figure 4.1 and listed in Table 4.2.

Table 4.2 Evaluation and Development Kit Inventory

Item	Description
Sensor	A12 sensor
Power supply	Wall-mount power supply, 12 VDC 800 mA
Cable	Cigaret lighter adapter cable
Cable	DB9 male-to-female I/O cable
Cable	Auxiliary cable, 1 PPS out, RTCM in
Manual	User guide
Floppy disk	Evaluator software

Step 2 - Load the Evaluate software into your computer

Refer to the Evaluate User's Guide P/N 630063. Follow the setup and software loading instructions in the guide.

When you load the Evaluate software into the PC, make sure the software version is 6.05 or later, earlier versions will not work with the A12. After your software is loaded, there is no need to launch the Evaluate application. You will be instructed to do this in a later step.

Step 3 - Prepare Your Equipment for Operation

Connect devices as shown in Figure 4.3. It is very important to follow instructions 1 through 6 below.

CAUTION
DO NOT connect power at any time during this step.

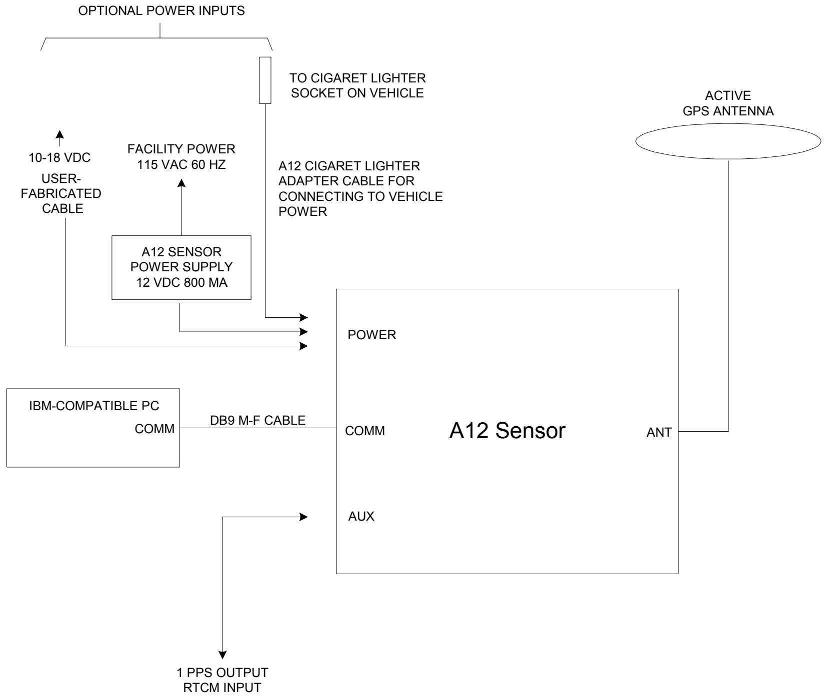

Figure 4.3: Setup Using A12 Development Kit

1. Connect the serial data cable DB9 M-F to the COMM port (DB9 connector) on the A12 sensor.
2. Connect the other end of the serial data cable to an initialized serial port on your IBM-compatible computer. If the serial port of your computer is not initialized, it will not be recognized by the Evaluate software.

Within the A12 sensor, the RTS/CTS lines of the interface cable are connected. This is done to ensure that your computer will always receive an immediate CTS signal when it asserts RTS as part of its communication process. Refer to Table 4.3 on page 34 for specific interconnection details.

3. Connect the power connector on the A12 sensor to the appropriate adapter (power supply, vehicle cigarette lighter, or external DC power source) but **DO NOT** connect power at this time.
4. Connect the antenna to the GPS ANT connector on the back of the A12 Sensor. You may connect a different active antenna to the A12 Sensor, but please refer to Table 1.6 on page 8 for antenna specifications. If it requires a voltage level other than 4.5 VDC, you must supply your own external power and use a DC block at this connector in order to ensure reliable operation of your antenna and A12 Sensor.

CAUTION
You must provide a DC block if you are providing external power to the antenna.

   Also note that if you are using a passive antenna with the A12 Sensor, make sure that it has enough gain to provide the RF signal strength needed at the input to the OEM board for reliable operation. The suggested RF cable length for a passive antenna is six inches. If you use your own antenna, it must meet the specifications listed in Table 1.6 on page 8.

5. If you are using the 1PPS output, connect the 1 PPS output and signal ground from the auxiliary cable connector on the A12 sensor to the appropriate recording device.
6. If you are using RTCM corrections, connect RTCM IN and signal ground from the auxiliary cable connector to the device port that is outputting the RTCM corrections.

Power and Signal Connections

Figure 4.4 shows the physical configuration of the connector pinouts. Table 4.3 defines power and input/output signals.

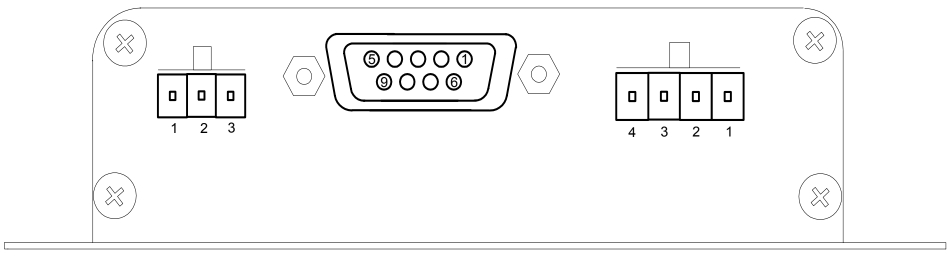

Figure 4.4: Connector Pinouts

Table 4.3 Power/Input/Output Connections

Connector	Pin	Signal	Function
Power In	1	Ground	BLACK - Chassis ground (= 12 VDC return)
	2	Power return	DC ground
	3	Power In (DC)	10-18 VDC +
COMM (DB9 M-F)	1	CD	Carrier detect out - true (+V) when power applied to A12. Tied to DSR.
	2	RXD	Received data out - TXD from A12
	3	TXD	Transmitted data in - RXD into A12‘
	4	DTR	Data terminal ready - not connected
	5	Ground	Signal ground - connected to DC return in A12
	6	DSR	Data set ready out - true (+V) when power applied to A12. Tied to CD
	7	RTS	Request to send in - tied to CTS in A12
	8	CTS	Clear to send out - tied to RTS in A12
	9	RI	Ring indicator out - not connected
Auxiliary	1	1 PPS out	Brown wire - Unbuffered TTL output
	2	Ground	Red wire - Signal ground for 1 PPS
	3	RTCM IN	Orange wire - RS-232 RXD (RTCM) into A12
	4	Ground	Yellow wire - Signal ground for RTCM IN

Step 4 - Position the GPS Antenna

Regardless of the antenna you use, it is very important that the antenna have a clear view of the entire sky. Obstructions may cause satellites to be hidden from view, creating a situation where the A12 will be unable to provide a position report.

Be aware that your receiver reports the position of the **GPS antenna**, not the position of the receiver. Please take this into account when making accuracy measurements.

When the A12 Sensor is connected to power it automatically provides +5VDC power to its internal A12 OEM board and 4.5 VDC power to the GPS antenna connector on the rear of the A12 Sensor. The 4.5VDC power signal on the antenna connector is designed for the antenna included in the kit. To ensure reliable operation, simply connect the antenna to the antenna connector and locate the antenna such that it has a clear view of the entire sky.

"Clear view of the entire sky" means exactly that. Locating the antenna on top of your computer monitor inside your office does not provide a clear view of the sky. Moving it to a window may help, but the window provides only a partial view of the sky. Generally, for optimum operation your antenna must be outside, away from any natural or man-made object that obstructs or reflects radio frequency signals. Failure to locate the antenna with a clear view of the sky will impact A12 start time and accuracy.

Step 5 - Power On the Equipment

Once you have completed steps 1 through 4, you are ready to power on your equipment. Ensure that, if you are using your own antenna, it meets the specifications listed in Table 1.6 on page 8, and it operates at 4.5 VDC. If it does not operate at 4.5 VDC, you must provide the correct voltage and must have installed a DC block between the SMA connector on the A12 Sensor rear panel and your antenna cable.

Connect the power cable to a power source. The PWR ON light should now be lit.

When the A12 Sensor is turned on for the first time, be aware of the following conditions:

1. The first power-on may require that A12 search several minutes to lock on to enough satellites to compute a position, assuming the antenna has a clear view of the entire sky. If the antenna is obstructed, the initial start may take longer to acquire satellites. "Cold starts" will typically take around 2 minutes.

CAUTION

If the A12 has a valid almanac and ephemeris, but has retained a last known position more than 1000 km from its actual location, the receiver should be reset using the $PASHS,INI command to minimize start time. If not reset, this condition may cause a long delay in the start time of the receiver.

2. The A12 serial interface turns on at 4800 baud. Your external device (e.g., P.C.) must initially communicate with the A12 at this rate. After communication is established, you can use the PC to change the baud rate.
3. Once the A12 is powered on and has completed its initial start process, it immediately begins calculating position. To output position messages, you must turn on the outputs you want by using the external device (PC) to issue the appropriate commands (refer to Chapter 5). The messages will contain valid data once the A12 has completed its cold, warm, or hot start sequence.
4. Once the A12 starts tracking satellites and has a valid position fix, the green tracking LED flashes once every second.

The Evaluate software provides simple communication programs designed to interface to A12 Sensor. Move on to Step 6 to initiate communication with the A12 Sensor.

Ashtech recommends that first time users always operate the A12 Sensor first with Evaluate software. Once operation is understood, use Evaluate or other terminal program to send any set or query commands defined in Chapter 5. For configuring A12 Sensor for

RTCM operation, refer to Chapter 3, *Operation* and Chapter 5, *Command/Response Formats*.

Step 6 - Using Evaluate Software

With your A12 Sensor powered on, you are ready to communicate to it using the Evaluate software. Open the Evaluate application on your computer. When the **Evaluate** opening screen, Figure 4.5, appears select the appropriate activity in the **Start From** menu; for the first start-up, this selection will be **Connect to GPS Receiver**. From this point on, follow the instructions in the Evaluate User's Guide.

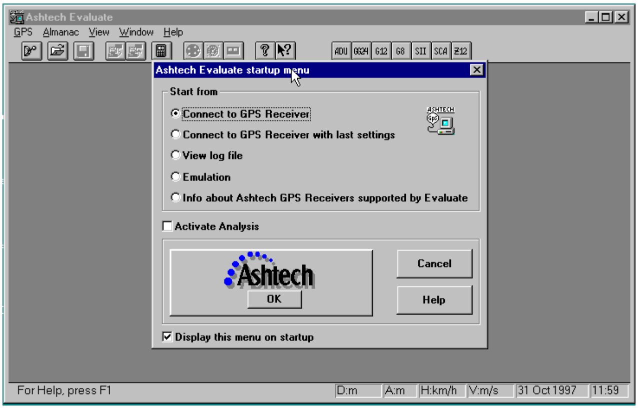

Figure 4.5: Evaluate Opening Screen

5

Command/Response Formats

Overview

This chapter details the formats and content of the serial port commands through which the receiver is controlled and monitored. These serial port commands set receiver parameters and request data and receiver status information. Use the program REMOTE.exe software or any other standard serial communication software (including Ashtech's Evaluate Software) to send and receive messages. Note that the baud rate and protocol of the computer COM port must match the baud rate and protocol of the receiver port for commands and data to be successfully transmitted and received. The receiver default protocol setting is 8 data bits, 1 stop bit, no parity, and 4800 baud.

All commands sent by the user to the receiver are either **Set** commands or **Query** commands. **Set** commands generally change receiver parameters and initiate data output. **Query** commands generally request receiver status information. All set commands begin with the string $PASHS and all query commands begin with the $PASHQ string. $PASHS and $PASHQ are the message header and are required for all commands. All commands must end with <Enter> or <CR><LF> to transmit the command to the receiver. If desired, an optional checksum may precede the <Enter> characters. All response messages end with a <CR><LF>.

The serial commands are presented in three separate groups:

- **General Receiver commands** - relate to general receiver operations. The discussion of these commands begins on page 41.
- **NMEA message commands** - control standard NMEA data message output or NMEA style message output. The discussion of these commands begins on page 60.
- **RTCM commands** - control RTCM differential operation. The discussion of these commands begins on page 87.

Within each group, the commands are listed alphabetically and described in detail. Information about the command includes the syntax, a description, the range and default, and an example of how the command is used. The syntax includes the number and type of parameters that are used or required by the command. These parameters may be either characters or numbers depending upon the particular command. The parameter type is indicated by the symbol that is a part of the syntax. Table 5.1 defines the parameter symbols.

Table 5.1 Command Parameter Symbols

Symbol	Parameter Type	Example
d	Numeric integer	3
f	Numeric real	2.45
c	1 character ASCII	N
x	1 character ASCII	A
s	Character string	UDD
m	Mixed parameter (integer and real)	3729.12345
h	Hexadecimal digit	FD2C

For example, for the receiver command

$PASHS,ALT,f

the parameter f indicates that the command accepts a single parameter that is a real number such as 0.5 or 10.0. If a character is entered instead, the command will be rejected. Generally speaking, the parameter must be in the specified format to be accepted. However, most parameters that are real numbers (f) will also accept an integer. For example, in the case of the ALT command the receiver will accept both 10 and 10.0.

Receiver Commands and Responses

The receiver commands are used to change or display various receiver operating parameters such as antenna position and PDOP mask. Commands may be sent to the receiver through any available serial port.

A12 utilizes two serial ports. Port A is full duplex and is used as the primary two-way communication port for the receiver. When commands are input to this port, the A12 returns the appropriate response to this port. Port B is half-duplex, therefore it accepts input messages but does not output messages. Port B is used primarily for inputting RTCM correction messages. It is possible to send a Set or Query command to port B, but the command must specify that the response message be sent to port A by using an "A" in the command field that identifies the serial port to which the response should be sent. If this is not done, a command sent to port B will generate no response through port A or B. In fact, there is no response feedback through port B to indicate if the command was rejected or accepted.

Set Commands

The general structure of the set commands is:

$PASHS,str,x <Enter>

where **str** is a 3-character string identifier, and **x** is one or more data parameters that will be sent to the receiver. For example, the set command to change the altitude of the antenna to 100.25 meters is:

$PASHS,ALT,+100.25 <Enter>

If a set command is accepted, an acknowledgment is returned in the form:

$PASHR,ACK*3D

If a set command is not accepted, an non-acknowledgment is returned in the form **$PASHR,NAK*30**. If a command is not accepted, check that the command has been typed correctly, and that the number and format of the data parameters are correct.

Query Commands

The general structure of the query command is:

$PASHQ,str,x <Enter>

where **str** is a 3-character string identifier and **x** is the serial port where the response message will be sent. The serial port field is optional. If the serial port is not included in a query command, the response is sent to the current port. For example, if you are communicating with the receiver on Port A and send the following query command:

$PASHQ,PRT <Enter>

the response will be sent to port A.

Responses to query and set commands are only sent to port A. If a query command is sent to port B, the port field must be included and must be set to port A. The resulting response will then be output through port A.

The response message may be in comma-delimited or free-form table format, depending upon the query command. Be aware that not every set command has a corresponding query command or response message.

Table 5.2 summarizes the set and query commands that do not have standard NMEA or NMEA style responses. These are used primarily to set receiver parameters or query receiver for parameters. Commands that generate standard NMEA responses are described in “NMEA Data Message Commands & Responses” on page 60. The pages shown in the table presents detailed descriptions of each command/query/response.

Table 5.2 Summary of General Receiver Set/Query Commands

Command	Description	Page
$PASHS,ALM	Upload almanac data	44
$PASHS,ALT	Set ellipsoidal height of antenna	45
$PASHS,DTM	Select datum to use	45
$PASHS,FIX	Set altitude position fix mode	46
$PASHS,HDP	Set HDOP mask for position computation	46
$PASHS,INI	Initialize receiver, set baud rate to specified value	47
$PASHS,LTZ	Set local time zone	48
$PASHQ,PAR	Receiver parameters query	48
$PASHS,PDP	Set PDOP mask	50
$PASHS,PEM	Set position elevation mask angle	50
$PASHS,PMD	Set position mode	51
$PASHS,POS	Set antenna position	51
$PASHS,PPO	Set point positioning mode	52
$PASHQ,PPO	Query point positioning status	52
$PASHQ,PRT	Serial port baud rate query	53
$PASHQ,RID	Receiver identification query	54
$PASHS,RST	Reset receiver parameters to default values	54
$PASHS,RTC	Set receiver to RTCM remote mode	90
$PASHQ,RTC	Query RTCM status	88
$PASHS,SAV	Save user parameters.	55
$PASHS,SPD	Set serial port speed	55
$PASHS,UDD	Set user-defined datum parameters	56
$PASHQ,UDD	Query user-defined datum parameters	57
$PASHS,UID	Set unit ID number	57
$PASHQ,UID	Query unit ID	57
$PASHS,USE	Set satellites to track or not track	58
$PASHS,WAS	Enable/disable WAAS reception	58
$PASHS,ZDA	Upload initial real-time clock value	58

ALM: Upload Almanac Data

$PASHS,ALM

Allows data to be loaded into the almanac store. This is used during aided initialization, and should be used if it is known that the data available to the receiver is invalid. The structure is

$PASHS,ALM,d1,d2,h1,h2,h3,h4,h5,h6,h7,h8,h9,h10,h11

where the parameters are as defined in Table 5.3.

Table 5.3 ALM Parameters

Parameter	Description	Range
d1	Satellite PRN number	1...32
d2	GPS week	0...9999
h1	SV health (in ASCII hex)	2 bytes
h2	Eccentricity (in ASCII hex)	4 bytes
h3	Almanac reference time (in ASCII hex)	2 bytes
h4	Inclination angle (semicircles - in ASCII hex)	4 bytes
h5	Rate of ascension (semicircles - in ASCII hex)	4 bytes
h6	Root of semi-major axis (in ASCII hex)	6 bytes
h7	Argument of perigee (semicircle - in ASCII hex)	6 bytes
h8	Longitude of ascension mode (semicircle - in ASCII hex)	6 bytes
h9	Mean anomaly (semicircle - in ASCII hex)	6 bytes
h10	Clock parameter (seconds - in ASCII hex)	3 bytes
h11	Clock parameter (sec/sec - in ASCII hex)	3 bytes

Data is in the format of the NMEA almanac message ($GPALM). The data should be sent using 32 separate messages, one per satellite.

In normal usage, this command should not be needed. However, it can be used in cases where it is known that the almanac data is significantly different, as it speeds up acquisition of the satellites.

ALT: Set Ellipsoidal Height of Antenna

$PASHS,ALT

Sets the ellipsoidal height of the antenna, where f = ±99999.99 meters and must include the sign (+ or -). The receiver uses this data in the position calculation for 2-D position computation. The structure is

$PASHS,ALT,f1

where the parameters are as defined in Table 5.4.

Table 5.4 ALT Parameters

Parameter	Description	Range
sign		+ or -
value	Altitude in meters. Default is 0.	0...99999.99

Example: Set ellipsoidal height of antenna to 100.25 meters:

$PASHS,ALT,+100.25 <Enter>

Example: Set ellipsoidal height of antenna to -30.1 meters:

$PASHS,ALT,-30.1 <Enter>

DTM: Select Datum to Use

$PASHS,DTM

Selects the geodetic datum used for position computation and measurements, where s is a 3-character string that defines a particular datum or USR (user-defined datum). Parameters for a user-defined datum are entered with the **$PASHS,UDD** command. WGS-84 is the default datum. If this command is used to select a datum but no datum has been entered via the UDD command, then the output remains WGS-84.

Example: Select user-defined datum for position computation:

$PASHS,DTM,USR <Enter>

where the parameters are as defined in Table 5.5.

Table 5.5 DTM Parameters

Parameter	Description	Range
USR	WGS-84 or user-defined using the command $PASHS,UDD.	W84 or USR

FIX: Altitude Position Fix Mode

$PASHS,FIX

Sets altitude hold position fix mode for the altitude used (for 2D position determination), where d is 0 or 1. This command must be used with the $PASHS,PMD command. The default is 0. The structure is

$PASHS,FIX,d

where d is as defined in Table 5.6.

Table 5.6 FIX Parameters

Parameter	Description
d	d = 0 (default): The most recent antenna altitude is used in antenna hold position computation. The altitude is taken from either the altitude entered by the $PASHS,ALT command, or the last altitude computed. d = 1: Always use the altitude set by the $PASHS,ALT command.

Example: Fix altitude to always use the entered altitude:

$PASHS,FIX,1 <Enter>

HDP: Set HDOP Mask

$PASHS,HDP

Set the value of the Horizontal Dilution of Precision (HDOP) mask, where d is a number between 0 and 99 (default = 4). The HDOP mask is used to set accuracy limits on A12 position outputs while operating in the fixed 2D mode. In this mode, if HDOP is exceeded no position is output. In 3D mode the HDOP mask is ignored. The command structure is

$PASHS,HDP,d

where d is the value of the HDOP mask as defined in Table 5.7.

Example: Set HDOP mask to 6.

$PASHS,HDP,6 <Enter>

Table 5.7 HDOP Parameters

Parameter	Range	Range
d	Value of the HDOP mask. Default is 4.	0...99

INI: Receiver Initialization

$PASHS,INI,d1,d2,d3,d4,d5,c1

The INI command resets the receiver memory, and sets the serial port baud rate to the specified rates. Unlike other set commands, if the INI command is successfully entered, then the receiver does not return a receiver acknowledgement ($PASHR,ACK), but immediately starts the initialization. The parameters are as defined in Table 5.8.

Table 5.8 INI Parameters

Parameter	Description	Range	Default
d1	Port A baud rate code: 2 = 1200 4 = 4800 5 = 9600 6 = 19200 8 = 57600 9 = 115200	2 - 9	4 (4800 baud)
d2	Port B baud rate code	0-6	4
d3	Reserved	null	n/a
d4	Reserved	null	n/a
d5	Memory reset code 0 = no memory reset 1 = reset internal memory 5 = clear ephemeris but not almanac, position, or time	0, 1,5	n/a
c1	Reserved	null	n/a

Parameters d3, d4, and c1 must be entered as null (i.e., include commas), or the command will respond with NAK.

Example: Set baud rate of port A to 4800, port B to 4800, and reset all memory.

$PASHS,INI,4,4,,,1, <Enter>

LTZ: Set Local Timezone

$PASHS,LTZ

Sets the timezone offset to be added to local time to get GMT. The structure is

$PASHS,LTZ,d1,d2

where the parameters are defined in Table 5.9. The response is ACK/NAK.

Table 5.9 LTZ Parameters

Parameter	Description	Range
d1	GMT = local time + time offset: hours	± 00...13
d2	GMT = loca ltime + time offset: minutes	00...59

The default is 00,00 i.e. a time offset of zero. This command affects the output of the $GPZDA response.

PAR: Receiver Parameter Query

$PASHQ,PAR

Returns the status of general receiver parameters. The structure is

$PASHQ,PAR,x

where x is the optional output port (A is the only valid value for x).

A typical response is shown below.

```
PMD:4      FIX:0       PEM:05 PDP:06 HDP:04
DTM:W84    LTZ:+00,00      SAV:N
USE:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
CDS:  AUTO   DIF_RTCM_MODE:OFF   PRT:B   AUT:Y   MAX:0015
LAT:0000.000000,N LON:00000.000000,E     ALT:+00000.00
NMEA:   ALM GGA GLL GSA GSV MSG POS RMC SAT VTG  ZDA
PRTA:   ---  ---  --- ---  ---  ---  ---  ---  ---  ---  ---
PER:    001.0
SPD:  PORT A: 5       PORT B: 5
ANT: Y
WAAS: Y
```

CAUTION

The $PASHQ,PAR response message is free-form and subject to change in future firmware versions. These messages are not intended to be computer-readable.

Table 5.10 defines the response parameters.

Table 5.10 PAR Parameters

Parameter	Description/Related Command	Range
PMD	Navigation position mode ($PASHS,PMD)	0 or 2
FIX	Altitude fix mode ($PASHS,FIX)	0 or 1
PEM	Position elevation mask ($PASHS,PEM)	0-90
PDP	PDOP mask ($PASHS,PDP)	0-99
HDP	HDOP mask ($PASHS,HDP)	0-99
DTM	Select datum ($PASHS,DTM)	W84 or USR (user)
USE	Use satellite ($PASHS,USE)	Y or N for each satellite
LTZ	Local timezone ($PASHS,LTZ)	-13,59 to +13,59
SAV	Save parameters ($PASHS,SAV)	Y (yes) or N (no)
CDS	Manual satellite selection ($PASHS,CDS)	AUTO (applies to all channels) or else PRN or - for each channel
DIF_RTCM MOD	RTCM differential mode ($PASHS,RTC)	OFF/REM
PRT	Port receiving RTCM ($PASHS,RTC)	A, B
AUT	Auto differential mode ($PASHS,RTC,AUT)	Y or N
MAX	RTCM maximum age ($PASHS,RTC,MAX)	0-3600
LAT	Latitude of antenna position ($PASHS,POS)	0-90, north or south
LON	Longitude of antenna position ($PASHS,POS)	0-180, east or west
ALT	Ellipsoidal height of antenna ($PASHS,ALT)	0-99999.99
NMEA	NMEA message type for output	
PRTA	Output to port A: period (if enabled) or disabled ($PASHS,NME)	Message enabled: 1-999 Message disabled: "_"
PER	NMEA message output period ($PASHS,NME $PASHS,NME,PER)	1-999.0
SPD	Indicates baud rate code for port A and port B ($PASHS,SPD)	2 = 1200 6 = 19200 4 = 4800 7 = 57600 5 = 9600 9 = 115200

Table 5.10 PAR Parameters (continued)

Parameter	Description/Related Command	Range
ANT	Antenna status	Y = antenna detected O = no antenna connected S = short circuit in antenna connection
WAAS	SBAS reception enabled or disabled	Y = enabled, N = disabled

PEM: Set Position Elevation Mask Angle

$PASHS,PEM

Sets the elevation mask for position computation. The structure is

$PASHS,PEM,d

where d is 0 to 90 degrees. Default is 0 degrees. Satellites with elevation less than the elevation mask will not be used for position computation.

Example: Set position elevation mask to 15 degrees

$PASHS,PEM,15 <Enter>

PDP: Set PDOP Mask for Position Computation

$PASHS,PDP

Sets the Position Dilution of Precision (PDOP) mask. If the PDOP mask is exceeded, no navigation solution is reported. The PDOP mask is used to set accuracy limits on position outputs while operating in 3D mode. If PDOP is above the PDOP mask, no position is output. In fixed 2D mode, the PDOP mask is ignored. The command structure is

$PASHS,PDP,d

where the parameter d is as defined in Table 5.11.

Table 5.11 PDP Parameters

Parameter	Description	Range
d	Dilution of precision	0...99 Default = 6

PMD: Set Navigation Position Mode

$PASHS,PMD

This command changes the receiver mode to 2D or 3D. The structure is

$PASHS,PMD,d

where d is as described in Table 5.12.

In 2D or when altitude is held fixed, the horizontal position is subject to greater error.

Table 5.12 PMD Parameters

Parameter	Description	Range
d	2: 2D position is generated; altitude is held fixed 4: 3D position is generated. Default is 4.	2 or 4

When PMD is set to 4, altitude is held fixed at the last computed value and does not use altitude entered by the ALT command.

POS: Set Antenna Position

$PASHS,POS

Sets the position of the antenna. The command structure is

$PASHS,POS,m1,c1,m2,c2,f1

where the parameters are as defined in Table 5.13.

This command is most often used to load a position to help receivers without battery backup to improve satellite acquisition times.

Table 5.13 POS Parameters

Field	Description	Range
m1	Latitude in degrees, decimal minutes (ddmm.mmmmmm)	0 to 90.0
c1	North (N) or South (S)	N or S
m2	Longitude in degrees, decimal minutes (dddmm.mmmmmm)	0 to 90.0
c2	East (E) or West (W)	E or W
f1	Ellipsoidal height in meters	-99999.999 to +99999.999

Example: Set antenna position (latitude and longitude):

$PASHS,POS,3722.291213,N,12159.799821,W,+15.25 <Enter

CAUTION
Entering an incorrect position can cause a very long delay in acquiring satellites.

PPO: Point Positioning

$PASHS,PPO,c

This command enables/disables point positioning mode, where c is Y (enable) or N (disable). Point positioning is an averaging algorithm that improves the stand-alone accuracy of a static point after about 4 hours.

Example: Enable point positioning:

$PASHS,PPO,Y <Enter>

$PASHQ,PPO

Query point positioning mode.

$PASHR,PPO

Point positioning response message. The response is in the form:

$PASHR,PPO,c

where c is Y (enabled) or N (disabled).

PRT: Serial Port Baud Rate Query

$PASHQ,PRT

Displays the baud rate setting for the connected communication port. The structure is

$PASHQ,PRT,x

where x is the optional output port. Note that to direct the response message to the current communication port, the x is not required.

Example: Query the baud rate of the current port:

$PASHQ,PRT <Enter>

$PASHR,PRT

The response to a serial port baud rate query is a message in the format:

$PASHR,PRT,x,d*cc

where the parameters are as defined in Table 5.14.

Table 5.14 PRT Parameters

Field	Description	Range
x	Serial port	A or B
d	Baud rate code	2 = 1200 4 = 4800 5 = 9600 6 = 19200 8 = 57600 9 = 115200
*cc	Checksum	n/a

RID: Receiver ID Query

$PASHQ,RID

Requests information about the receiver type, firmware, and available options. The structure is

$PASHQ,RID,c

where c is the optional output port. If c is not specified, output goes to the current port.

Example: Query the current port for receiver identification

$PASHQ,RID <Enter>

$PASHR,RID

The return message is in the form:

$PASHR,RID,EX,s1,*cc

where the parameters are as defined in Table 5.15.

Table 5.15 $PASHR,RID Structure

Parameter	Description	Range
s1	Firmware version	4 characters

Example: Query: $PASHQ,RID <Enter>

Response: $PASHR,RID,EX,HM00

RST: Reset Receiver

$PASHS,RST

Resets the receiver parameters to their default values. The RST command resets all parameters to their default values. For more information on default values, see Chapter 6.

Example: Reset receiver parameters

$PASHS,RST <Enter>

SAV: Save User Parameters

$PASHS,SAV

This command saves the current parameters of the system to battery-backed RAM. At the next power-on (e.g. hardware reset to exit the power saving mode) these saved parameters are restored. The structure is

$PASHS,SAV,c

where the c parameter is Y (yes) or N (no). Y saves parameters now, and restores them after a hard reset. N returns parameters to default values the next time the receiver is powered on.

Once the $PASHS,SAV,Y command is issued, all user parameters that were changed before power-down will be saved.

If the command $PASHS,SAV,N is sent, the parameters of the system are always set to default values the next time the receiver is powered up.

The response is ACK/NAK.

CAUTION
Battery backup voltage must be applied to A12 pin 3 (V-back) for new parameters to be saved after power to the A12 pin (VCC) has been removed.

SPD: Set Serial Port Speed

$PASHS,SPD

Sets the baud rate of the receiver serial port. The structure is

$PASH,SPD,c,d

where c is port A or B, and d is a number between 0 and 9 specifying the baud rate as listed in Table 5.16. Default is 4800 baud. To resume communication

Table 5.16 SPD Parameters

Code	Baud Rate	Code	Baud Rate
2	1200	6	19200
4	4800	8	57600
5	9600	9	115200

with the receiver after changing the baud rate using this command, be sure to change the baud rate of the command device.

Example: Set port A to 19200 baud:

$PASHS,SPD,A,6 <Enter>

UDD: Set User-Defined Datum Parameters

$PASHS,UDD

Sets the user-defined datum parameters in the receiver memory. The structure is:

$PASHS,UDD,d1,d2,f1,f2,f3,f4,f5,f6,f7,f8

where the parameters are as defined in Table 5.17.

Table 5.17 UDD Structure

Field	Description	Range	Units
d1	Geodetic datum ID. Always 0 for WGS 84.	0	n/a
d2	Semi-major axis	6300000.0- 6400000.0	meters
f1	Flattening in meters.	290.0 to 300.0	meters
f2	Translation in x direction	-1000.0 to +1000.0	meters
f3	Translation in y direction	-1000.0 to +1000.0	meters
f4	Translation in z direction	-1000.0 to +1000.0	meters
f5	Rotation in x axis + rotation is counterclockwise - rotation is clockwise rotation.	Always 0.0	radians
f6	Rotation in y axis	Always 0.0	radians
f7	Rotation in z axis	Always 0.0	radians
f8	Scale factor. Range -10.00 to +10.00.	Always 0.0	n/a

Fields f5 - f8 are reserved for future use and should always be set to zero.

Example: Set datum parameters:

$PASHS,UDD,0,637 8240, 297.3, 34.2, 121.4, 18.9, 0, 0, 0, 0 <Enter>

$PASHQ,UDD

The associated query command is $PASHS,UDD,a where a is the optional output port and is not required to direct the response message to the current communication port.

Example: Query datum parameters to port A

$PASHQ,UDD,A <Enter>

$PASHR,UDD

The response is in the format.

$PASHR,UDD,d1,d2,f1,f2,f3,f4,f5,f6,f7,f8*cc

where the fields are as defined in Table 5.17.

UID: Unit Identification

$PASHS,UID

Sets the unit ID for the receiver. The structure is

$PASHS,UID,s

where s is a 4-character unit identification number selected by the user. The UID set command also sets the unit identification number in the POS message.

Example: Set unit ID to A179:

$PASHS,UID,A179<Enter>

$PASHQ,UID

The associated query command is $PASHQ,UID,c   where c is the optional output port. This query returns the unit ID to the specified port. Port A is the only valid value for s.

$PASHR,UID

The response is in the format

$PASHR,UID,d*cc

where d is the unit identification number.

Example: **$PASHR,UID,A179**

If no value has been entered using the $PASHS,UID command, the default value (null) is reported in the $PASHR,UID response and the $PASHR,POS response.

USE: Set Satellites to Use

$PASHS,USE

Selects satellites to track or not track. The structure is

$PASHS,USE,d,c

where d is the PRN number of the satellite (range from 1 to 32) or ALL for all satellites, and c is Y (enable) or N (disable).

Example: Do not track satellite 14

$PASHS,USE,14,N <Enter>

WAS: Wide-Area Augmentation

$PASHS,WAS,ON/OFF

This command enables/disables the reception of SBAS (WAAS/EGNOS/MSAS) signals. When turned off the receiver uses all 12 channels for tracking GPS satellites. The $PASHQ,PAR and $PASHQ,RTC query commands can be used to view current WAAS settings.

ZDA: Upload Initial Real-time Clock Value

$PASHS,ZDA

Allows data to be loaded into the real-time clock. This is used to aid acquisition for receivers that use no battery backup. In normal usage, this command should not be needed. However, it can be used if it is known that the clock data is significantly different, as it will speed up acquisition of the satellites. The command structure is

$PASHS,ZDA,f1,d1,d2,d3,d4

where the parameters are as defined in Table 5.18.

Table 5.18 ZDA Parameters

Parameter	Description	Range
f1	UTC time (hhmmss.ss)	000000.00 through 235959.99

Table 5.18 ZDA Parameters (continued)

Parameter	Description	Range
d1	UTC day (dd)	01 through 31
d2	UTC month (mm)	01 through 12
d3	UTC year (yyyy)	0000 through 9999
d4	UTC time zone offset. Must be null.	Null

The time zone offset field must be null. Any other value will generate a NAK response.

CAUTION

Entering the wrong time can cause long delays in acquiring satellites.

Example: Upload real-time clock values where the UTC time is 13:1530 on 1/15/98 and the local time is 8:15:30:

$PASHS,ZDA,131530.00,01,15,1998 <Enter>

NMEA Data Message Commands & Responses

The NMEA message commands control all query and set commands related to NMEA format messages and miscellaneous messages in an Ashtech NMEA style format. All standard NMEA messages are a string of ASCII characters delimited by commas, in compliance with NMEA 0183 Standard Version 3.0. All non-standard messages are a string of ASCII characters delimited by commas in the Ashtech NMEA style format. Any combination of these messages can be output as long as the character I/O rate for the receiver is not exceeded (400 characters per second). The output interval is determined by the $PASHS,NME,PER command or the specific $PASHS,NME command, and can be set to any value between 1 and 999 seconds.

For each NMEA message type there is a set command, a query command and a response message. The set command is used to continuously output the NMEA response message at the specified period. The query outputs a NMEA response message only once.

Set Commands

The general structure of the NMEA set commands is

$PASHS,NME,str,x,s,d <Enter>

where x is the serial port to which the response message should be sent, s is either ON or OFF, and d is an optional parameter to specify the reporting interval. ON enables the message and OFF disables the message. The **str** is a 3-character string that identifies the NMEA message to be output. If the reporting interval is not set, the output interval set by the $PASHS,NME,PER command is used. The available strings are:

ALM, GGA, GLL, GSA, GSV, MSG, POS, RMC, SAT, VTG, ZDA

When a set command is sent correctly, the receiver sends a $PASHR,ACK (command acknowledge) message. If the command is sent incorrectly or the syntax is wrong, the receiver sends a $PASHS,NAK (command not acknowledged) message. Once acknowledged, the receiver will output the corresponding NMEA data message at the interval defined, unless a necessary condition for the message to be output is not present.

Port A is the only port that can be used to output NMEA messages.

To disable all NMEA messages, use the $PASHS,NME,ALL command.

To see what NMEA messages have been enabled, use the $PASHQ,PAR command.

Example: Enable GGA message on port A:

$PASHS,NME,GGA,A,ON <Enter>

Example: Output enabled NMEA messages every 5 seconds:

$PASHS,NME,PER,5 <Enter>

Query Commands

The general structure of the NMEA query commands is:

$PASHQ,str,x, <Enter>

where str is one of the 3-character NMEA strings and **x** is the serial port to where the response message will be sent (port A is the only valid port). The serial port field is optional. If a port is not included, the receiver sends the response to the current port. Unlike the set commands, the query command initiates a single response message.

Example: Query POS message and send the response to port A:

$PASHQ,POS,A <Enter>

Example: Query GSA message and send the response to the current port:

$PASHQ,GSA <Enter>

If the optional port field is not included, the query must be sent from port A, as messages can not be output to port B.

Table 5.19 summarizes the NMEA data message commands and responses. A detailed description of each NMEA command follows Table 5.19.

Table 5.19 NMEA Data Message Commands and Responses

Command	Description	Page
$PASHS,NME,ALL	Disable all NMEA messages	63
$PASHS,NME,ALM	Enable/disable almanac data message	63
$PASHQ,ALM	Query almanac data message	63
$GPALM	GPS almanac response message	63
$PASHS,NME,GGA	Enable/disable position response message	66
$PASHQ,GGA	Query position response message	66
$GPGGA	Position response message	66
$PASHS,NME,GLL	Enable/disable latitude/longitude message	69
$PASHQ,GLL	Query latitude/longitude message	69
$GPGLL	Latitude/longitude response message	69
$PASHS,NME,GSA	Enable/disable satellites used message	71
$PASHQ,GSA	Query satellite used message	71
$GPGSA	Satellites used response message	71
$PASHS,NME,GSV	Enable/disable satellites in view message	72
$PASHQ,GSV	Query satellites in view message	73
$GPGSV	Satellites-in-view response message	73
$PASHS,NME,PER	Set send interval - all NMEA messages	74
$PASHS,NME,POS	Enable position message	75
$PASHQ,POS	Position message query	75
$PASHR,POS	Position response message	75
$PASHS,NME,RMC	Enable recommended minimum course response message	78
$PASHQ,RMC	Recommended minimum course query	78
$GPRMC	Recommended minimum course response message	78
$PASHS,NME,SAT	Enable/disable satellite status message	80
$PASHQ,SAT	Satellite status query	81
$PASHR,SAT	Satellite status response message	81
$PASHS,NME,VTG	Enable/disable velocity/course message	83
$PASHQ,VTG	Query velocity/course message	83
$GPVTG	Course over ground and ground speed response message	83
$PASHS,NME,ZDA	Enable/disable time and date message	85
$PASHQ,ZDA	Query time and date message	85
$GPZDA	Time and date response message	85

ALL: Disable All NMEA Messages

$PASHS,NME,ALL

Turn off all enabled NMEA messages. The structure is:

$PASHS,NME,ALL,x,OFF

where x is the specified serial port.

Example: Turn off all NMEA message currently sent out through port A:

$PASHS,NME,ALL,A,OFF <Enter>

ALM: Almanac Message

$PASHS,NME,ALM

Enable/disable the almanac message. The structure is:

$PASHS,NME,ALM,x,s,d

where x is the receiver serial port, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds.

Example: Enable ALM message on port A, reporting interval 5 seconds:

$PASHS,NME,ALM,A,ON,5 <Enter>

$PASHQ,ALM

The associated query command is $PASHQ,ALM,x, where x is the optional output port.

Example: Query almanac data message to receiver port A:

$PASHQ,ALM,A <Enter>

$GPALM

There is one response message for each satellite in the GPS constellation. The response to the set or query command is in the form

$GPALM,d1,d2,d3,d4,h1,h2,h3,h4,h5,h6,h7,h8,h9,h10,h11*cc

where the parameters are as defined in Table 5.20.

Table 5.20 GPALM Response Message Structure

Field	Description	Range
d1	Total number of messages	01 -32
d2	Number of this message	01 -32
d3	Satellite PRN number	01 - 32
d4	GPS week	4 digits
h1	SV health (In ASCII hex)	2 bytes
h2	Eccentricity (In ASCII hex)	4 bytes
h3	Almanac reference time (seconds. In ASCII hex)	2 bytes
h4	Inclination angle (semicircles. In ASCII hex)	4 bytes
h5	Rate of ascension (semicircles/sec. In ASCII hex)	4 bytes
h6	Root of semi-major axis (In ASCII hex)	6 bytes
h7	Argument of perigee (semicircle. In ASCII hex)	6 bytes
h8	Longitude of ascension mode (semicircle. In ASCII hex)	6 bytes
h9	Mean anomaly (semicircle. In ASCII hex)	6 bytes
h10	Clock parameter (seconds. In ASCII hex)	3 bytes
h11	Clock parameter (sec/sec. In ASCII hex)	3 bytes
*cc	Checksum	

Example:

Query: $PASHQ,ALM <Enter>

Typical response (Table 5.21):

$GPALM,26,01,01,0899,00,1E8C,24,080B,FD49,A10D58,EB4562,BFEF85,227A5B,011,000*0B

Table 5.21 Typical GPALM Response Message

Item	Significance
$GPALM	Header
26	Total number of messages
01	Number of this message
01	Satellite PRN number
0899	GPS week number
00	Satellite health
1E8C	Eccentricity
24	Almanac reference time
080B	Inclination angle
FD49	Rate of ascension
A10D58	Root of semi-major axis
EB4562	Argument of perigree
BFEF85	Longitude of ascension mode
227A5B	Mean anomaly
011	Clock parameter
000	Clock parameter
*0B	checksum

GGA: GPS Position Message

$PASHS,NME,GGA

This command enables/disables the GPS position message. The structure is

$PASHS,NME,GGA,x,s,d

where x is port A or B, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds. If no position is being computed, an empty message is output. Default is **disabled**.

Example: Enable GGA on port A:

$PASHS,NME,GGA,A,ON <Enter>

$PASHQ,GGA,x

The associated query message is $PASHQ,GGA,x where x is optional the receiver port where the message will be output. If no position is being computed, an empty message is output.

Example: $PASHQ,GGA <Enter>

$GPGGA

The GGA response message is not output unless position is computed. The response message is in the form:

$GPGGA,m1,m2,c1,m3,c2,d1,d2,f1,f2,M,f3,M,f4,d3*cc

Table 5.22 GGA Message Structure

Parameter	Description	Range
m1	Current UTC time of position fix in hours, minutes, and seconds (hhmmss.ss)	00-235959.99
m2	Latitude component of position in degrees and decimal minutes (ddmm.mmmmmm)	0-90
c1	Direction of latitude N= North, S= South	N or S
m3	Longitudinal component of position in degrees and decimal minutes (dddmm.mmmmmm)	0-180
c2	Direction of longitude E = East, W= West	E or W
d1	Position type: 0. Invalid or not available 1. Autonomous position 2. RTCM or SBAS differentially corrected	0, 1, 2
d2	Number of satellites used in position computation	0 - 12
f1	Horizontal dilution of precision (HDOP)	0 - 99.9
f2	Altitude in meters above the reference ellipsoid. For 2-D position computation, this item contains the user- entered altitude used to compute the position computation.	-30000.00 to 30000.00
M	Altitude units M = meters	M
f3	Geoidal separation in meters	±999.99
M	Geoidal separation units M = meters	M
d3	Age of differential corrections (seconds)	0-999 (RTCM mode)
d4	Base station ID (RTCM only)	0-1023
cc	checksum	

CAUTION
Fields may contain old or erroneous data. Use the position type field to determine validity.

Note: The latency between 1 PPS pulse and GGA message is approximately 1 second.

Example: Query: $PASHQ,GGA <Enter>

A typical GGA response is shown below and described in Table 5.23.

$GPGGA,185333.00,3721.077440,N,12156.114654,W,2,08,1.0,
00036.81,M,-28.3,M,,*66

Table 5.23 Typical GGA Message

Field	Description
$GPGGA	Header
185333.00	UTC time
3721.077440	Latitude (ddmm.mmmmmm)
N	North latitude
12156.114654	Longitude (dddmm.mmmmmm)
W	West longitude
2	RTCM or SBAS differential position
08	Number of satellites used in position
1.0	HDOP
00036.81	Altitude
M	Units of altitude (M = meters)
-28.3	Geoidal separation
M	Units of geoidal separation (M=meters)
,,	Null field
*66	checksum

GLL: Latitude/Longitude Message

$PASHS,NME,GLL

This command enables/disables the latitude/longitude response message. The structure is

$PASHS,NME,GLL,x,s,d

where x is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds. If no position is being computed, an empty message is output.

Example: Enable GLL message on port A:

$PASHS,NME,GLL,A,ON <Enter>

$PASHQ,GLL

The associated query message is $PASHQ,GLL,x where x is the optional output serial port. If a port is not specified, the current port is used. If no position is being computed, an empty message is output.

Example: Display GLL message on current port:

$PASHQ,GLL <Enter>

$GPGLL

The response message is in the form shown below and defined in Table 5.24.

$GPGLL,m1,c1,m2,c2,m3,c3*cc

Table 5.24 GLL Message Structure

Field	Description	Range
m1	Latitude in degrees, decimal minutes (ddmm.mmmmmm)	0 - 90°
c1	Direction of latitude N = North, S = South	N or S
m2	Longitude in degrees, decimal minutes (dddmm.mmmmmm)	0 - 180°
c2	Direction of longitude W = West, E = East	W or E
m3	UTC time in hours, minutes, and seconds (hhmmss.ss)	00-235959.50
c3	Status, A: valid, V: invalid	A or V
c4	Mode indicator	A = autonomous D = differential E = estimated (dead reckoning) M = manual input S = simulator N = data not valid
*cc	Checksum	

Example: Query: $PASHQ,GLL <Enter>

Typical response:

$GPGLL,3721.0752,N,12156.1148,W,220949.00,A,A*75

Table 5.25 describes each item in a typical GLL response message.

Table 5.25 Typical GLL Response Message

Field	Description
$GPGLL	Header
3721.0752	Latitude
N	North latitude
12156.1148	Longitude
W	West longitude
220949.00,	UTC time of position
A	Status valid
A	Autonomous mode
*12	checksum

GSA: DOP and Active Satellite Messages

$PASHS,NME,GSA

This command enables/disables the DOP and active satellite message to be sent out to serial port x. The structure is

$PASHS,NME,GSA,x,s,d

where x is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds.

Example: Enable GSA message on port A:

$PASHS,NME,GSA,A,ON <Enter>

$PASHQ,GSA

The associated query message is $PASHQ,GSA,x where x is the optional output serial port.

Example: Display GSA message on the current port:

$PASHQ,GSA <Enter>

$GPGSA

The response message is in the form shown below and defined inTable 5.26.

$GPGSA,c1,d1,d2,d3,d4,d5,d6,d7,d8,d9,d10,d11,d12,d13,f1,f2,f3*cc

Table 5.26 GSA Message Structure

Field	Description	Range
c1	Mode: M: manual, A: automatic	M or A
d1	Mode: 1: fix not available 2: 2D 3: 3D	1 -3
d2 - d13	Satellites used in solution (null for unused channel)	1 -32
f1	PDOP	0 - 9.9
f2	HDOP	0 - 9.9
f3	VDOP	0 - 9.9
*cc	Checksum	

Example:

Query: $PASHQ,GSA <Enter>

A typical response is shown below and described in Table 5.27.

$GPGSA,M,3,,02,,04,27,26,07,,,,,,3.2,1.4,2.9*39

Table 5.27 Typical GSA Message

Item	Description
$GPGSA	Header
M	Manual mode
3	3D mode
empty field	Satellite in channel 1
02	Satellite in channel 2
empty field	Satellite in channel 3
04	Satellite in channel 4
27	Satellite in channel 5
26	Satellite in channel 6
07	Satellite in channel 7
empty field	Satellite in channel 8
empty field	Satellite in channel 9
empty field	Satellite in channel 10
empty field	Satellite in channel 11
empty field	Satellite in channel 12
3.2	PDOP
1.4	HDOP
2.9	VDOP
*38	checksum

GSV: Satellites in View Message

$PASHS,NME,GSV

This command enables/disables the satellites-in-view message on the serial port. The structure is

$PASHS,NME,GSV,x,s,d

where x is port A, s is ON or OFF, and d is the optional reporting interval from

1 to 999 seconds.

Example: Output GSV message on port A:

$PASHS,NME,GSV,A,ON <Enter>

$PASHQ,GSV

The associated query message is $PASHQ,GSV,x where x is the optional output serial port.

Example: Query the GSA message on port A:

$PASHQ,GSV,A <Enter>

$GPGSV

The response message is in the form:

$GPGSV,d1,d2,d3,n(d4,d5,d6,f1)*cc

where the fields are as described in Table 5.28.

Table 5.28 GSV Message Structure

Field	Description	Range
d1	Total number of messages	1-3
d2	Message number	1-3
d3	Total number of satellites in view	1-12
d4	Satellite PRN	1-32 for GPS 33 - 64 for SBAS
d5	Elevation in degrees	0-90
d6	Azimuth in degrees	0-359
d7	SNR in dB-Hz	30 - 60
*cc	checksum	

Example:

Query: $PASHQ,GSV <Enter>

Typical response:

$GPGSV,2,1,08,16,23,293,50.3,19,63,050,52.1,28,11,038,51.5,29,14,145,50.9*78

where each item is as described in Table 5.29.

Table 5.29 Typical GSV Message

Item	Description
2	Total number of messages 1..3
1	Message number 1..3
8	Number of SVs in view 1..12
16	PRN of first satellite 1..32
23	Elevation of first satellite 0..90
293	Azimuth of first satellite 0...351
50.3	Signal-to-noise of first satellite
19	PRN of second satellite
63	Elevation of second satellite
050	Azimuth of second satellite
52.1	Signal-to-noise of second satellite
28	PRN of third satellite
11	Elevation of third satellite
038	Azimuth of third satellite
51.5	Signal-to-noise of third satellite
29	PRN of fourth satellite
14	Elevation of fourth satellite
145	Azimuth of fourth satellite
50.9	Signal-to-noise of fourth satellite
78	Message checksum in hexadecimal

PER: Set NMEA Send Interval

$PASHS,NME,PER,d

Sets send interval of the NMEA response messages in seconds, where d is a value between 1 and 999.

Example: Output NMEA messages every 5 seconds:

$PASHS,NME,PER,5 <Enter>

Longer intervals conserve power.

If a $PASHS,NME,PER command is sent after individual NMEA message output periods were set, the previous individual message periods are superseded by the more recent NME,PER value.

POS: Position Message

$PASHS,NME,POS

Enable/disable NMEA position response message on specified port. The structure is

$PASHS,NME,POS,x,s,d

where x is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds. If no position is being computed, an empty message is output.

Example: Enable position message on port A:

$PASHS,NME,POS,A,ON <Enter>

$PASHQ,POS

The associated query command is $PASHQ,POS,x where x is the optional output serial port.

Example: Send POS message to current port:

$PASHQ,POS <Enter>

$PASHR,POS

The response message is in the form:

$PASHR,POS,d1,d2,m1,m2,c1,m3,c2,f1,f2,f3,f4,f5,f6,f7,f8,f9,s*cc

where the fields are as defined in Table 5.30.

Table 5.30 POS Message Structure

Parameter	Description	Range
d1	Raw/differential position 0: Raw position is not differentially corrected 1: Position is differentially corrected with RTCM or SBAS	0, 1
d2	Number of SVs used in position fix	3 through 12

Table 5.30 POS Message Structure (continued)

Parameter	Description	Range
m1	Current UTC time of position fix (hhmmss.ss)	00 through 235959.50
m2	Latitude component of position in degrees and decimal minutes (ddmm.mmmmmm)	0 through 90
c1	Latitude sector N = north S = south	N or S
m3	Longitude component of position in degrees and decimal minutes (ddmm.mmmmmm)	0 through 180
c2	Longitude sector E = east W = west	E or W
f1	Altitude in meters above WGS-84 reference ellipsoid. For 2-D position computation this item contains the altitude held fixed.	-30000.00 through 30000.00
f2	Unit ID or firmware version when no unit ID is input	0 to 4-character string
f3	True track/course over ground in degrees	0 through 359.9
f4	Speed over ground in kilometers per hour	0 through 999.9
f5	Vertical velocity in meters per second	-999.9 through +999.99
f6	PDOP - position dilution of precision	0 through 99.9
f7	HDOP - position dilution of precision	0 through 99.9
f8	PDOP - position dilution of precision	0 through 99.9
f9	TDOP - position dilution of precision	0 through 99.9
s	Firmware version ID	4-character string
*cc	checksum	

Example:

Query: $PASHQ,POS

Typical response:

$PASHR,POS,1,08,185333.00,3721.077440,N,12156.114654,W,00008.
50,A111,015.0,000.0,-00.0,1.8,1.0,1.5,1.0,HM00*7C

Table 5.31 describes each item in a typical POS message.

Table 5.31 Typical POS Message

Item	Description
$PASHR,POS	Header
0	Raw position, not differentially corrected
06	Number of SVs used in position fix
185333.00	UTC time of position fix
3722.385158	Latitude
N	North latitude
12156.114654	Longitude
W	West longitude
00008.50	Altitude above ellipsoid (meters)
A111	unit ID
015.0	Course over ground (degrees)
000.0	Speed over ground (km/hr)
-00.0	Vertical velocity (m/sec)
1.8	PDOP
1.0	HDOP
1.5	VDOP
1.0	TDOP
HM00	Firmware version ID
*7C	checksum

RMC: Recommended Minimum Course

$PASHS,NME,RMC

Enables or disables NMEA recommended minimum course on specified port. The command structure is

$PASHS,NME,RMC,c,s,d <Enter>

where c is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds. If no position is being computed, an empty message is output.

Example: Enable RMC message on port A at the PER period:

$PASHS,NME,RMC,A,ON <Enter>

Example: Enable RMC message on port A at 2-second period:

$PASHS,NME,RMC,A,ON,2 <Enter>

$PASHQ,RMC

The corresponding query command is $PASHQ,RMC,x where x is the optional output serial port. If no position is being computed, an empty message is output.

Example: Send RMC message to port A:

$PASHQ,RMC,A <Enter>

$GPRMC

The RMC response message is in the form:

$GPRMC,f1,c2,f3,c4,f5,c6,f7,f8,s9,f10,c11,c12*cc

where the parameters are as defined in Table 5.32.

Table 5.32 GPRMC Parameters

Field	Description	Range
f1	UTC time of the GGA fix associated with this sentence (hhmmss.ss)	000000.00...235959.00
c2	Status	A = data valid V = navigation receiver warning
f3	Latitude (ddmm.mmmm)	0000.0000...8959.99999
c4	Latitude direction	N = North S = South
f5	Longitude (dddmm.mmmm)	00000.0000...17959.9999
c6	Longitude direction	E = East W = West
f7	Speed over ground, knots	000.0...999.9
f8	Course over ground, degrees true	000.0...359.9
s9	Date, mmddyy	010100...123199
f10	Magnetic variation, degrees	0.00...99.99
c11	Direction of variation Easterly variation (E) subtracts from true course. Westerly variation (W) adds to true course.	E = East W = West
c12	Mode indicator	A = autonomous D = differential E = Estimated (dead reckoning) M = manual input S = simulator N = data not valid
*cc	Hexadecimal checksum computed by exclusive-ORing all bytes in the message between, but not including, the $ and the *. The result is *hh, where h is a hex character 0 - 9 or A-F.	0 through 9 or A through F

A typical response message is shown below and described in Table 5.33.

$GPRMC,215734.00,A,3721.0760,N,12156.1138,W,00.0,015.0,
040902,15,E,D*39

Table 5.33 Typical RMC Response Message

Item	Significance
$GPRMC	Header
215734.00	UTC time of GGA fix
A	Status valid
3721.0760	Latitude
N	North
12156.1138	Longitude
W	West
00.0	Speed over ground, knots
015.0	Course over ground, degrees true
040902	Date
15	Magnetic variation, degrees
E	East (subtracts from true course)
D	Differential
*39	Checksum

SAT: Satellite Status Query

$PASHS,NME,SAT

This command enables/disables the satellite status message to the specified port. The command structure is

$PASHS,NME,SAT,x,s,d

where x is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds.

Example: Enable SAT message on port A:

$PASHS,NME,SAT,A,ON <Enter>

$PASHQ,SAT

The associated query message is $PASHQ,SAT,x where x is the optional output serial port.

Example: Send SAT message to port A

$PASHQ,SAT,A <Enter>

$PASHR,SAT

The response message is in the form:

$PASHR,SAT,d1,n(d2,d3,d4,f1,c)*cc

where the parameters are as defined in Table 5.34.

Table 5.34 SAT Message Structure

Field	Description	Range
d1	Number of SVs locked	1 to 2
d2	SV PRN number,	1 to 32 for GPS 33 to 64 for SBAS
d3	SV azimuth angle in degrees	0 to 359
d4	SV elevation angle in degrees	0 to 90
f1	SV signal/noise ratio in dB Hz	30.0 to 60.0
c	SV used in position computation U = used, - = not used	U or -
*cc	checksum	

Example:

Query: $PASHQ,SAT

Typical response:

$PASHR,SAT,04,03,103,56,50.5,U,23,225,61,52.4,U,16,045,02,51.4,
U,40,160,46,53.6,U*6E

Table 5.35 describes each item in a typical SAT response message.

Table 5.35 Typical SAT Message

Item	Significance
$PASHR,SAT	Header
04	Number of SVs locked
03	PRN number of the first SV
103	Azimuth of the first SV in degrees
56	Elevation of the first SV in degrees
50.5	Signal strength of the first SV
U	SV used in position computation
23	PRN number of the second SV
225	Azimuth of the second SV in degrees
61	Elevation of the second SV in degrees
52.4	Signal strength of the second SV
U	SV used in position computation
16	PRN number of the third SV
045	Azimuth of the third SV in degrees
02	Elevation of the third SV in degrees
51.4	Signal Strength of the third SV
U	SV used in position computation
40	PRN number of fourth SV
160	Azimuth of fourth SV in degrees
46	Elevation of fourth SV in degrees
53.6	Signal strength of fourth SV
U	SV used in position computation
6E	Message checksum in hexadecimal

VTG: Velocity/Course Message

$PASHS,NME,VTG

This command enables/disables the velocity/course message. The structure is

$PASHS7,NME,VTG,x,s,d

where x is port A, s is ON or OFF, and d is the (optional) reporting interval from 1 to 999 seconds. If no position is being computed, an empty message is output. Default is **disabled**.

Example: Enable VTG message on port A, reporting interval 5 seconds:

$PASHS,NME,VTG,A,ON,5 <Enter>

$PASHQ,VTG

The associated query message is $PASHQ,VTG,x where x is the optional output serial port. If no position is being computed, an empty message is output.

Example: Send VTG message to port A:

$PASHQ,VTG,A <Enter>

$GPVTG

The response message is in the form:

$GPVTG,f1,T,f2,M,f3,N,f4,K,c5*cc

where the fields are as described in Table 5.36.

Table 5.36 VTG Message Structure

Field	Description	Range
f1	COG (Course Over Ground) true north	0 - 359.99
T	COG orientation (T = true north)	T
f2	COG magnetic north	0 - 359.99
M	COG orientation (M = magnetic north)	M
f3	SOG (Speed Over Ground) and N for knots	0 - 999.99
N	SOG units (N = knots)	N
f4	SOG (Speed Over Ground)	0 - 999.99
K	SOG units (K = Km/hr)	K
c5	Mode indicator	A = autonomous D = differential E = estimated (dead reckoning) M = manual input S = simulator N = data not valid
*cc	checksum	

Example:

Query: $PASHQ,VTG <Enter>

Typical response:

$GPVTG,004.58,T,349.17,M,000.87,N,001.61,K,A*46

Table 5.37 describes each item in a typical VTG message.

Table 5.37 Typical VTG Message

Item	Significance
$GPVTG	Header
004.58	Course over ground (COG) oriented to true north
T	True north orientation
349.17	Course over ground (COG) oriented to magnetic north
M	Magnetic north orientation
000.87	Speed over ground (SOG) in knots
N	SOG units (N=knots)
001.61	Speed over ground (SOG) in km/hr
K	SOG units (K=km/hr)
A	Autonomous mode
*46	checksum

ZDA: Time and Date

$PASHS,NME,ZDA

Enable/disable NMEA time and date message. The command structure is

$PASHS,NME,ZDA,x,s,d <Enter>

where x is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds.

Example: Enable ZDA message on port A at 10-second interval:

$PASHS,NME,ZDA,A,10 <Enter>

$PASHQ,ZDA

The associated query command is $PASHQ,ZDA,x where x is the optional output serial port.

Example: Send ZDA message to port A:

$PASHQ,ZDA,A <Enter>

$GPZDA

The NMEA time and date response message is in the form:

$GPZDA,f1,d1,d2,d3,d4,d5*cc

Table 5.38 defines each field of the $GPZDA message structure.

Table 5.38 GPZDA Time and Date Message Structure

Field	Description	Range
f1	UTC time	000000.00 through 235959.99
d1	Current day	01 through 31
d2	Current month	01 through 12
d3	Current year	0000 through 9999
d4	Local zone offset from UTC time (hours)	-13 through 13
d5	Local zone offset from UTC time (minutes)	0 through 59
*cc	Checksum	

Example:

Query: $PASHQ,ZDA,A <Enter>

Typical response: $GPZDA,132123.00,10,03,1996,07,00*ss

Table 5.39 describes each item in a typical $GPZDA response message.

Table 5.39 Typical GPZDA Response Message

Item	Description
123123.00	UTC time
10	Current day
03	Current month
1996	Current year
07	Local time zone offset (hours portion)
00	Local time zone offset (minutes portion)
*22	Checksum

RTCM Commands and Responses

The RTCM commands allow you to control and monitor RTCM real-time differential operations. For a more detailed discussion of RTCM differential, refer to the RTCM differential section of the Operations chapter.

Set Commands

All RTCM commands except one are **set** commands. Using the **set** commands, you can modify and enable a variety of differential parameters. If the **set** command is sent correctly, the receiver responds with the $PASHR,ACK acknowledgment. If a parameter is out of range or the syntax is incorrect, the receiver responds with a $PASHR,NAK to indicate that the command was not accepted.

Query Commands

There is only one **query** command: **$PASHQ,RTC**. Use this command to monitor the parameters and status of RTCM differential operations. The **query** command has an optional port field. If the query is sent with the port field empty, the response is sent to the current port. For example, the query

$PASHQ,RTC <Enter>

outputs an RTCM status message to the current port, while the command:

$PASHQ,RTC,A <Enter>

outputs an RTCM status message to port A. Table 5.40 summarizes the RTCM commands.

Table 5.40 RTCM Commands

Command	Description	Page
GENERAL PARAMETERS		
$PASHS,RTC,OFF	Disables differential mode	89
$PASHQ,RTC	Requests differential mode parameters and status	88
REMOTE PARAMETERS		
$PASHS,RTC,AUT	Turns auto differential mode on or off	89
$PASHS,RTC,MAX	Sets maximum age of RTCM differential corrections	89
$PASHS,RTC,REM	Sets receiver to operate as differential remote station	90

RTC: RTCM Status Query

$PASHQ,RTC

Queries the RTCM differential status. The structure is

$PASHQ,RTC,x

where x is the optional output port (A is the only valid value for port).

The return message is a free-form response format. A typical response message is shown below.

```
STATUS:
SYNC:*TYPE:00, STID:0000,  STHE:00,
AGE:0.00,QA:           ,OFFSET:    0,WAAS:Y
SETUP:
MODE:OFF, PORT:B, AUT:Y,MAX:0015
```

where the parameters are as defined in Table 5.41.

Table 5.41 RTC Parameters

Parameter	Description	Range
STATUS		
SYNC	Sync to last received RTCM message between receiver (remote) and base stations.	* = in sync
TYPE	RTCM message type being received.	1, 3, 9, 16
STID	Station ID received from the base station.	0...1023
STHE	Station health received from the base station.	0...7
AGE	Age of the received messages (seconds)	0...999
QA	Communication quality factor between base and remote (not implemented)	0...100%
OFFSET	Number of bits from beginning of RTCM byte (in case of bit slippage)	
WAAS	Indicates if WAAS corrections can be used in DGPS solution	Y = yes N = no
SETUP		
MODE	RTCM mode	REM, OFF
PORT	Communication port	A, B
AUT	Automatic differential mode	Y, N

Table 5.41 RTC Parameters (continued)

Parameter	Description	Range
MAX	Maximum age, in seconds, required for a message to be used	0...3599
MSG	Displays message up to 90 characters from base station (not implemented)	

AUT: Set Auto Differential Mode

$PASHS,RTC,AUT

Turns auto differential mode on or off. The structure is

$PASHS,RTC,AUT,c

where c is Y (or ON) or N (or OFF). When in auto-diff mode, the receiver generates uncorrected positions automatically if differential corrections are older than the maximum age, or are not available. Default is Y (ON).

Example: Turn auto differential mode off

$PASHS,RTC,AUT,N <Enter>

MAX: Set RTCM Differential Data Age

$PASHS,RTC,MAX

Set the maximum age in seconds of an RTCM differential correction above which it will not be used. The structure is

$PASHS,RTC,MAX,d

where d is any number between 1 and 1199. Default is 15.

Example: Set maximum age to 30 seconds:

$PASHS,RTC,MAX,30 <Enter>

OFF: Disable RTCM

$PASHS,RTC,OFF

Disables base or remote differential mode.

Example: Turn RTCM off:

$PASHS,RTC,OFF <ENTER>

REM: Enable Remote RTCM

$PASHS,RTC,REM

Sets receiver to operate as an RTCM differential remote station. The structure is

```
$PASHS,RTC,REM,x
```

where x is port A or B for differential inputs. If WAAS corrections are available, they will be used automatically. However, RTCM corrections through the serial port take priority over WAAS, i.e., if both corrections are available, RTCM corrections will be used in the position solution.

Example: Set receiver as differential remote using port B to input corrections:

```
$PASHS,RTC,REM,B <Enter>
```

6

Reference

Search Strategy & Position Algorithms

Satellite Selection

The search manager tracks the 12 satellites with the highest elevation. Only healthy satellites are tracked; unhealthy satellites are ignored. If fewer than 12 satellites are available above the horizon, the remaining channels are drawn from a list of all GPS satellites. The list is maintained in ROM.

During cold start conditions, when satellite visibility information cannot be computed, the search manager selects satellites by drawing in turn from the ROM list. This satellite selection maximizes the probability of quickly selecting a visible satellite.

When satellite visibility is available for only a subset of the satellites (e.g. for several minutes after cold start), the search manager selects the 12 satellites with the highest elevation with known visibility. If fewer than 12 satellites are known to be visible, the remaining channels are assigned to satellites with unknown visibility by drawing from the ROM list used for cold start.

False Position Condition

If the receiver has been powered on for five minutes and no position has been computed, one channel of the receiver is dedicated to sequentially searching for satellites that are calculated to be below the horizon. If any of these satellites are locked the search manager resets and performs a cold start.

Once a position is obtained, the search manager ceases searching for satellites below the horizon. The strategy can be re-invoked only by cycling power or resetting the receiver.

The intent here is to ensure that the receiver will successfully acquire even if the last known position is invalid or if the real-time clock time is incorrect.

CAUTION
If the A12 has a valid almanac and ephemeris, but has retained a last known position more than 1000 km from its actual location, the receiver should be reset using the $PASHS,INI command to minimize start time. If not reset, this condition may cause a long delay in the start time of the receiver.

Search Strategy

During normal operation conditions, the search strategy dedicates one channel to each satellite in the satellite assignment.

During startup and reacquisition conditions the search strategy dedicates seven or 12 channels to a single satellite for searching. Satellites are searched for sequentially, cycling among the highest five satellites in the satellite selection. This strategy improves acquisition time when the clock uncertainty is very large.

Position Modes

The A12 may operate in either of two modes to return a position computation. The $PASHS,PMD command, or equivalent, is used to select the mode.

3D Mode

3D mode is the standard mode of operation. In 3D mode, four satellites are required to be locked for the initial position fix. After the initial fix, however, there is no requirement for any particular number of satellites to be locked. Rather, A12 continues to operate by using whatever satellites are locked, propagating its internal solution and reporting the predicted position until PDOP exceeds PDOP mask. Latitude, longitude, altitude, and time are computed in this mode.

2D Mode

In 2D mode as set by the user, the A12 calculates latitude, longitude, and time, and holds altitude constant. The value to use for altitude is determined by the $PASHS,ALT and $PASHS,FIX commands.

When FIX is set to 1, the 2D altitude is always the altitude entered via the $PASHS,ALT command. However, when FIX is set to 0, the altitude is the most-recently-determined altitude, which may be either that entered via the $PASHS,ALT command, or the altitude from the last computed 3D determination that passed the PDOP test.

The A12 requires at least three satellites to be locked for the initial 2D position fix. After the initial fix, however, there is no requirement for any particular number of satellites to be locked. Rather, A12 continues to operate by making use of whatever satellites are locked, propagating its internal solution and reporting the predicted position until HDOP exceeds HDOP mask.

Missile Technology Control Regime (MTCR)

Whenever the A12 has calculated a position and has determined that either the A12 altitude is greater than 60,000 feet (18,288 m), or the velocity is greater than 1,000 knots (514 m/sec), then the MTCR limits are considered to be exceeded. In either case, the A12 produces no valid position information.

Other Operational Characteristics

Conversions

The A12 can perform the following conversions:

- Convert latitude and longitude rates to course over ground (COG) and speed over ground (SOG). In case of speeds below 1 m/s, the last known course is held.
- Convert course over ground from true bearing to magnetic bearing. This is computed from a table containing global magnetic variations.
- Convert altitude from height above WGS-84 ellipsoid to mean sea level, using a table containing a geoid undulation model

Self Test

Built In Test (BIT) algorithms determine the general health of the A12 memory and verify the integrity of information saved in backup RAM. Invalid data are not used.

Watchdog Timer

The A12 utilizes a watchdog timer to enable it to recover from firmware errors. In normal operation, the timer is regularly reset. If an irreversible firmware error occurs, the timer will expire and the receiver automatically restarts.

System Parameter Settings

The A12 can save all current parameter settings using a $PASHS command such that during a power interruption these settings will be utilized when power is restored. A $PASHS command can also be used to revert to default settings.

Long-Term Operation

The A12 is capable of long-term non-stop operation. None of the following events will affect operation or cause any change in performance during continuous operation for one week:

- Week rollover (weekly)
- Leap second change

Datum Support

The standard datum supported is WGS-84. Other datums (user-defined) can be loaded using the $PASHS,UDD command described on page 56.

Detailed Performance Characteristics

Accuracy

A12 accuracy is defined in terms of horizontal 95% and circular error probable (CEP) as listed in Table 6.1. All measurements assume SA is off.

Table 6.1: Accuracy Specifications (Low multipath environment)

Mode	A12	Test Conditions
Autonomous CEP (50%)	3 m	Autonomous guidelines:
Autonomous horizontal 95%	5 m	Precision antenna
Autonomous vertical 95%	7.5 m	10° elevation angle
Autonomous speed	0.2 km/h	
Autonomous directional at 40 km/h	0.2 degree	
DGPS using SBAS Horizontal CEP (50%)	1 m	SBAS guidelines
DGPS using SBAS Horizontal CEP (95%)	3 m	Precision antenna
DGPS using SBAS Vertical CEP (95%)	4.5 m	10° elevation angle
DGPS CEP (50%)	0.8 m	DGPS guidelines
DGPS horizontal 95%	1.5 m	Precision antenna
DGPS vertical (95%)	2.25 m	10° elevation angle

Table 6.1: Accuracy Specifications (Low multipath environment) (continued)

Mode	A12	Test Conditions
DGPS speed	0.1 km/h	Test horz. position per note 4 below
DGPS directional at 40 km/h	0.1°	Test speed and direction per note 3 below

ACCURACY NOTES:

1. Horizontal 95% accuracy definition: The circle, centered at the known antenna position, that contains 95% of the points in a horizontal scatter plot.

2. CEP accuracy definition: The circle, centered at the known antenna position, that contains 50% of the points in a horizontal scatter plot. This is the same as typical accuracy, since half the positions are more accurate than this, half are less accurate.

3. Speed and Direction: Measured with simulator, without S/A, speed 40 km/h.

4. Measure DGPS accuracy using an Ashtech G12 reference station with Marine/Survey antenna on a short baseline (<10km), with a rate of differential corrections set at once per second at 300bps. Disregard wireless communication latency by utilizing hardwire connection.

5. Accuracy measurement assumes the antenna has a clear view of the sky and uses the highest satellites above a 10° elevation, with HDOP ≤4, PDOP ≤6.

TTFF (Time To First Fix)

TTFF (Time To First Fix) is defined as the time from when the receiver is turned on to the time that three or more satellites are tracked and a valid position is calculated. Performance is as specified in Table 6.2.

Table 6.2: TTFF and Reacquisition Performance

Mode	Typical Example	Approximate Position (w/in several 100 km)	Valid Almanac	Valid Ephemeris (2-4 hours old)	Valid Time (w/in 10 min)	Average Time in Seconds (50th percentile)
Cold start - TTFF	Fresh out of the box	no	no	no	no	150

Reference

Table 6.2: TTFF and Reacquisition Performance (continued) (continued)

Mode	Typical Example	Approximate Position (w/in several 100 km)	Valid Almanac	Valid Ephemeris (2-4 hours old)	Valid Time (w/in 10 min)	Average Time in Seconds (50th percentile)
Warm start TTFF	Receiver off over-night	yes	yes	no	yes	45
Hot start-TTFF	Receiver off at lunch	yes	yes	yes	yes	10

TTFF NOTES:

For a receiver that starts with an estimated position which is wildly incorrect (the estimated position is the diametrically-opposite point on the earth) the TTFF time is approximately 25 minutes in the warm start and hot start cases.

Four satellites (3D) are required for cold start in the default configuration. The receiver may be commanded to start in a 3-satellite mode (2D).

CAUTION

If the A12 has a valid almanac and ephemeris, but has retained a last known position more than 1000 km from its actual location, the receiver should be reset using the $PASHS,INI command to minimize start time. If not reset, this condition may cause a long delay in the start time of the receiver.

Reacquisition Times

Reacquisition is defined as the time between signal blockage from all satellites and the time that three or more satellites are tracked and a valid position is calculated. Performance is as specified in Table 6.3.

Table 6.3: Reacquisition Times

Mode	Description	Typical Example	Average (50th Percentile)
Reacquisition (<20 sec blockage)	Temporary blockage	Under over-pass	1 to 2 sec
Reacquisition (<180 sec blockage)	Temporary blockage	In short tunnel	3 to 5 sec

7

Troubleshooting

Listed below are some tests and fixes for common problems that you may encounter when installing and configuring the A12 GPS OEM board.

TTL-to-RS-232 Conversion

If you are using a TTL-to-RS-232 converter for your A12 OEM board, verify that the level conversion is correct (i.e., 5 volts to 12 volts), as described in “Communication Port Setup” on page 14.

Port Setup

Verify the port default setup of 8 bits, no parity, 1 stop bit, 4800 baud as described in “Communication Port Setup” on page 14. This setup must be consistent with the communication parameters used by your computer or other processing device.

RTS/CTS

RTS/CTS are connected together in the A12 Evaluator, but not in the A12 OEM board. If you do not have the A12 Evaluator, your will have to manage the RTS/CTS required by your computer or other processing device, as described in “RTS/CTS Considerations” on page 15.

Factory Defaults

To clear unknown parameters, you can reset to factory defaults using the $PASHS,INI command, as described on page 47.

Saving Parameters

If you are losing your user-defined parameters during a power cycle, be sure to save them prior to the power cycle by using the $PASHS,SAV,Y command, as described on page 55. Also, for parameters to be saved through a power cycle, there must be appropriate battery backup power provided at pin 3 (V_BACK).

Logging Data

Ashtech does not recommend logging data with unique PC application programs other than Ashtech’s Evaluate program.

Using Third Party Software

When using third party software like Hyperterminal, ensure CR/LF outgoing is enabled. All set commands and queries end with CR/LF.

A

Global Product Support

If you have any problems or require further assistance, you can contact Technical Support by telephone, email, or Internet.

Please refer to the documentation before contacting Technical Support. Many common problems are identified within the documentation and suggestions are offered for solving them.

Ashtech Products Technical Support, Santa Clara CA USA

800 Numberr 800-229-2400, Option 1

Direct dial: (408) 615-3980

Switchboard: (408) 615-5100

FAX line: (408) 615-5200

e-mail: ashtechsupport@thalesnavigation.com

Internet: http://www.ashtech.com

Nantes, France:

Direct dial: 33 2 2809 3934

Switchboard: 33 2 2809 3800

e-mail: technical@thalesnavigation.com

Ashtech South America:

Tel: +56 2 234 56 43

FAX: +56 2 234 56 47

When contacting Technical Support, please have the following information:

Receiver serial number

Software version number

Software key serial number, if applicable

Firmware version number

A clear, concise description of the problem.

Solutions for Common Problems

- Check cables and power supplies. Many hardware problems are related to these simple problems.
- If the problem seems to be with your computer, re-boot it to clear RAM.
- If you are experiencing receiver problems, reset the receiver as documented in the set commands section of this manual. Reset clears receiver memory and resets operating parameters to factory defaults.
- Verify that the batteries are charged.
- Verify that the antenna view of the sky is unobstructed by trees, buildings, or other canopy.
- Click on Evaluate "Create Support Ticket" and e-mail the file to Technical Support.

Corporate Web Page

You can obtain data sheets, GPS information, application notes, and a variety of useful information from Ashtech's Internet web page at:

http://www.ashtech.com

Repair Centers

In addition to repair centers in California and England, authorized distributors in 27 countries can assist you with your service needs.

Thales Navigation

469 El Camino Real

Santa Clara California 95050-4300

Voice: (408) 615-3980 or (800) 229-2400, Option 2

FAX: (408) 615-5200

e-mail: rmaprocessing@thalesnavigation.com

Ashtech Europe Ltd.

First Base, Beacontree Plaza

Gillete Way

Reading RG2 OBP

United Kingdom

Tel 44 118 931 9600 FAX: 44 118 932 9601

Glossary

Aerotriangulation (phototriangulation)
A complex process vital to aerial **Photogrammetry** that involves extending vertical and/or horizontal control so that the measurements of angles and/or distances on overlapping photographs are related to a spatial solution using the perspective principles of the photographs. Aerotriangulation consists of mathematically extending the vectors/angles of the triangular pattern of known reference points on or near the designated photo-block terrain upward through a rectangle representing the area of the photo-block (as seen by the camera's optical center) in such a way that the tree-point terrain triangle and the camera's eye three-point triangle (within the photographic frame) are analogous.

AFT
After

AGE
Age of Data

ALM
See **Almanac**

Almanac
A set of parameters used by a GPS receiver to predict the approximate locations of all GPS satellites and the expected satellite clock offsets. Each GPS satellite contains and transmits the almanac data for all GPS satellites (See **Ellipsoid**).

ALT
Altitude

Ambiguity
The initial bias in a carrier-phase observation of an arbitrary number of carrier cycles; the uncertainty of the number of carrier cycles a receiver is attempting to count. If wavelength is known, the distance to a satellite can be computed once the number of cycles is established via carrier-phase processing.

AMI
ATM Management Interface

ANT
Antenna

Antenna
A variety of GPS antennas ranging from simpler microstrip devices to complex choke ring antennas that mitigate the effects of multipath scattering.

Anti-Spoofing (AS)
The process of encrypting the P-Code modulation sequence so the code cannot be replicated by hostile forces. When encrypted, the **P-Code** is referred to as the **Y-Code**.

ASCII
American Standard Code for Information Interchange. A set of characters (letters, numbers, symbols) used to display and transfer digital data in human-readable format.

Atomic clock
A clock whose frequency is maintained using electromagnetic waves that are emitted or absorbed in the transition of atomic particles between energy states. The frequency of an atomic transition is very precise, resulting in very stable clocks. A cesium clock has an error of about one second in one million years. For

redundancy purposes, GPS satellites carry multiple atomic clocks. GPS satellites have used rubidium clocks as well as cesium clocks. The GPS Master Control Station uses cesium clocks and a hydrogen master clock.

Argument of latitude
The sum of the true anomaly and the argument of perigee.

Argument of perigee
The angle or arc from the ascending node to the closest approach of the orbiting body to the focus or perigee, as measured at the focus of an elliptical orbit, in the orbital plane in the direction of motion of the orbiting body.

Ascending node
The point at which an object's orbit crosses the reference plane (e.g., equatorial plane) from south to north.

Bandwidth
A measure of the information-carrying capacity of a signal expressed as the width of the spectrum of that signal (frequency domain representation) in Hertz.

Baseline
The measured distance between two receivers or two antennas

Bias
See **Integer bias terms**

BIN
Binary Index (file)

C/A
Coarse Acquisition

C/A code
A sequence of 1023 bits (0 or 1) that repeats every millisecond. Each satellite broadcasts a unique 1023-bit sequence that allows a receiver to distinguish between various satellites. The C/A-Code modulates only the L1 carrier frequency on GPS satellites. GPS satellite navigation signals are broadcast on two L-band frequencies, L1 is 1575.42 MHz, and L2 is 1227.6 MHz.

Carrier phase
The phase of either the L1 or L2 carrier of a GPS signal, measured by a receiver while locked-on to the signal (also known as integrated Doppler).

CEP
Circular error probable. That vertical circle through the elevated celestial pole, It also passes through the other celestial pole, the astronomical zenith, and the nadir..

Channel
Refers to the hardware in a receiver that allows the receiver to detect, lock on, and continuously track the signal from a single satellite. The more receiver channels available, the greater number of satellite signals a receiver can simultaneously lock-on and track.

Chip
The length of time to transmit either a zero or a one in a binary pulse code..

Chip rate
Number of chips per second (e.g., C/A code = 1.023 MHz).

Circular Error Probable
The radius of a circle, centered at the true location, within which 50% of position solutions fall. CEP is used for horizontal accuracy..

Clock offset
The difference in time between GPS time and a satellite clock or a sensor clock (less accurate). radios use the same frequency both with each one having a separate and unique code. GPS uses CDMA techniques with Gold's code from their unique cross-correlation properties.

COG
Course Over Ground

Constellation
Refers to the collection of orbiting GPS satellites. The GPS constellation consists of 24 satellites in 12-hour circular orbits at an altitude of 20,200 kilometers. In the nominal constellation, four satellites are spaced in each of six orbital planes. The constellation was selected to provoke a very high probability of satellite coverage even in the event of satellite outages..

CTD
Course To Destination

Cycle slip
A loss of count of carrier cycles as they are being measured by a GPS receiver. Loss of signal, ionospheric interference and other forms of interference cause cycle slips to occur.

DGPS
Differential Global Positioning System

Differential GPS (DGPS)
A technique whereby data from a receiver at a known location is used to correct the data from a receiver at an unknown location. Differential corrections can be applied in real-time or by post-processing. Since most of the errors in GPS are common to users in a wide area, the DGPS-corrected solution is significantly more accurate than a normal SPS solution.

Differential processing
GPS measurements can be differenced between receivers, satellites, and epochs. Although many combinations are possible, the present convention for differential processing of GPS measurements is to take differences between receivers (single difference), then between satellites (double difference), then between measurement epochs (triple difference). A single-difference measurement between receivers is the instantaneous difference in phase of the signal from the same satellite, measured by two receivers simultaneously. A double-difference measurement is the difference for a chosen reference satellite. A triple-difference measurement is the difference between a double difference at one epoch and the same double difference at the previous epoch.

Differential (relative) positioning
Determination of relative coordinates of two or more receivers which are simultaneously tracking the same satellites. Dynamic differential positioning is a real-time calibration technique achieved by sending corrections to the roving user from one or more reference stations. Static differential GPS involves determining baseline vectors between pairs of receivers.

Dilution of Precision (DOP)
A measure of the receiver-satellite(s) geometry. DOP relates the statistical accuracy of the GPS measurements to the statistical accuracy of the solution. Geometric Dilution of Precision (GDOP) is composed of Time Dilution of Precision (TDOP); and Position Dilution of Precision (PDOP), which are composed of Horizontal Dilution of Precision (HDOP); and Vertical Dilution of Precision (VDOP).

DOP
Dilution of Precision

Doppler aiding
The use of Doppler carrier-phase measurements to smooth code-phase position measurements.

Doppler shift
An apparent change in signal frequency which

occurs as the transmitter and receiver move toward or away from one another.

Double difference
The arithmetic differencing of carrier phases measured simultaneously by a pair of receivers tracking the same pair of satellites. Single differences are obtained by each receiver from each satellite; these differences are then differenced in turn, which essentially deletes all satellite and receiver clock errors.

DTD
Distance to Destination

Dynamic positioning
Determination of a timed series of sets of coordinates for a moving receiver, each set of coordinates being determined from a single data sample, and usually computed in real-time.

Earth Centered, Earth Fixed (ECEF)
A cartesian coordinate system centered at the earth's center of mass. The Z-axis is aligned with the earth's mean spin axis. The X-axis is aligned with the zero meridian. The Y-axis is 90 degrees west of the X-axis, forming a right-handed coordinate system. ellipse to its focus to the semimajor axis. e = (1 - b2/a2)-1/2 where a and b are the semimajor and semiminor axes of the ellipse.

EDOP
Elevation Dilution of Precision

ELEV
Elevation

Elevation
Height above mean sea level. Vertical distance above the geoid.

Elevation mask
An adjustable feature of GPS receivers that specifies that a satellite must be at least a specified number of degrees above the horizon before the signals from the satellite are to be used. Satellites at low elevation angles (five degrees or less) have lower signal strengths and are more prone to loss of lock thus causing noisy solutions.

Elevation mask angle
That angle below which it is not advisable to track satellites. Normally set to 15 degrees to avoid interference problems caused by buildings and trees and multipath reflections.

Ellipsoid
In geodesy, unless otherwise specified, a mathematical figure formed by revolving an ellipse about its minor axis. It is often used interchangeably with spheroid. Two quantities define an ellipsoid; the length of the semimajor axis, a, and the flattening, f =- (a - b)/a, where b is the length of the semiminor axis. Prolate and triaxial ellipsoids are invariably described as such.

Ellipsoid height
The measure of vertical distance above the ellipsoid. Not the same as elevation above sea level. GPS receiver output position fix height in the WGS-84 datum.

Ephemeris
A set of parameters used by a GPS receiver to predict the location of a single GPS satellite and its clock behavior. Each GPS satellite contains and transmits ephemeris data for its own orbit and clock. Ephemeris data is more accurate than the almanac data but is applicable over a short time frame (four to six hours). Ephemeris data is transmitted by the satellite every 30 seconds.

Epoch
Measurement interval or data frequency, as in making observations every 15 seconds. Loading data using 30-second epochs means

loading every other measurement.

FCC
Federal Communications Commission

Firmware
The coded instructions relating to receiver function, and (sometimes) data processing algorithms, embedded as integral portions of the internal circuitry.

Flattening
f = (a- b)/a = 1 - (1 - e2) 1/2 where
a = semimajor axis
b = semiminor axis
e = Eccentricity

GDOP
Geometric Dilution of Precision. The relationship between errors in user position and time and in satellite range. $GDOP^2 = PDOP^2 + TDOP^2$. See Position Dilution of Precision.
.

Geodetic datum (horizontal datum)
A specifically oriented ellipsoid typically defined by eight parameters which establish its dimensions, define its center with respect to Earth's center of mass and specify its orientation in relation to the Earth's average spin axis and Greenwich reference meridian.

Geodetic height (ellipsoidal height)
The height of a point above an ellipsoidal surface. The difference between a point's geodetic height and its orthometric height equals the geoidal height.

Geoid
The equipotential surface of the Earth's gravity field which best fits mean sea level. Geoids currently in use are GEOID84 and GEOID90.

Geoidal height (geoidal separation; undulation)
The height of a point on the geoid above the ellipsoid measured along a perpendicular to the ellipsoid.

GLL
Position Latitude/Longitude

GMST
Greenwich Mean Sidereal Time

GPS DIFF
Differential

GPS ICD-200
The GPS Interface Control Document is a government document that contains the full technical description of the interface between the satellites and the user. GPS receiver must comply with this specification if it is to receive and process GPS signals properly.

GPS week
GPS time started at Saturday/Sunday midnight, January 6, 1980. The GPS week is the number of whole weeks since GPS time zero.

Greenwich mean time (GMT)
See universal time. In this text, they are often used interchangeably.

HDOP
Horizontal Dilution of Precision. See Dilution of Precision.

HI
Height of Instrument

HTDOP
Horizontal/Time Dilution of Precision. See Dilution of Precision.

ID
Identification or Integrated Doppler

Integer bias terms
The receiver counts the carrier waves from the satellite, as they pass the antenna, to a high

degree of accuracy. However, it has no information of the number of waves to the satellite at the time it started counting. This unknown number of wavelengths between the satellite and the antenna is the integer bias term.

Integrated Doppler
A measurement of Doppler shift frequency or phase over time.

Ionosphere
Refers to the layers of ionized air in the atmosphere extending from 70 kilometers to 700 kilometers and higher. Depending on frequency, the ionosphere can either block radio signals completely or change the propagation speed. GPS signals penetrate the ionosphere but are delayed. The ionospheric delays can be predicted using models, though with relatively poor accuracy, or measured using two receivers.

Ionospheric delay
A wave propagating through the ionosphere [which is a nonhomogeneous (in space and time) and dispersive medium] experiences delay. Phase delay depends on electron content and affects carrier signals. Group delay depends on dispersion in the ionosphere as well, and affects signal modulation (codes). The phase and group delay are of the same magnitude but opposite sign.

Julian date
The number of days that have elapsed since 1 January 4713 B.C. in the Julian calendar. GPS time zero is defined to be midnight UTC, Saturday/Sunday, 6 January 1980 at Greenwich. The Julian date for GPS time zero is 2,444,244.5.

Kalman filter
A numerical method used to track a time-varying signal in the presence of noise. If the signal can be characterized by some number of parameters that vary slowly with time, then Kalman filtering can be used to tell how incoming raw measurements should be processed to best estimate those parameters as a function of time.

Kinematic surveying
A method which initially solves wavelength ambiguities and retains the resulting measurements by maintaining a lock on a specific number of satellites throughout the entire surveying period.

L1
The primary L-band signal radiated by each NAVSTAR satellite at 1575.42 MHz. The Ll beacon is modulated with the C/A and P codes, and with the NAV message. L2 is centered at 1227.60 MHz and is modulated with the P code and the NAV message.

L1 & L2
Designations of the two basic carrier frequencies transmitted by GPS satellites that contain the navigation signals. L1 is 1,575.42 MHz and L2 is 1,227.60 MHz.

Lane
The area (or volume) enclosed by adjacent lines (or surfaces) of zero phase of either the carrier beat phase signal or of the difference between two carrier beat phase signals. On the earth's surface a line of zero phase is the focus of all points for which the observed value has an exact integer value for the complete instantaneous phase measurement. In three dimensions, this locus becomes a surface.

L-band
A nominal portion of the microwave electro-magnetic spectrum ranging from 390 MHz to 1.55 GHz.

LNA
Low-Noise Amplifier

MSG
RTCM Message

MSL
Mean Sea Level

Multichannel receiver
A receiver containing many independent channels. Such a receiver offers highest SNR because each channel tracks one satellite continuously.

Multipath
The reception of a signal both along a direct path and along one or more reflected paths. The resulting signal results in an incorrect pseudorange measurement. The classical example of multipath is the "ghosting" that appears on television when an airplane passes overhead.

Multipath error
A positioning error resulting from interference between radio waves which have traveled between the transmitter and the receiver by two paths of different electrical lengths.

Multiplexing
A technique used in some GPS receivers to sequence the signals of two or more satellites through a single hardware channel. Multiplexing allows a receiver to track more satellites than the number of hardware channels at the cost of lower effective signal strength.

Multiplexing channel
A receiver channel which is sequenced through several satellite signals (each from a specific satellite at a specific frequency) at a rate which is synchronous with the satellite message bit-rate (50 bits per second, or 20 milliseconds per bit). Thus, one complete sequence is completed in a multiple of 20 milliseconds.

NMEA
National Marine Electronics Association

NV
Non-Volatile. Usually refers to a memory device that retains data after power is removed.

Outage
The occurrence in time and space of a GPS dilution of precision value exceeding a specified maximum.

P-Code
Precise or protected code which is bi-phase shift modulated on both the L1 and L2 carrier frequencies. P-code has a 10.23MHz bit rate and, as implemented in GPS, a period of 267 days. Each satellite has a unique one-week P-code segment that is used to distinguish the satellite from all other GPS satellites.

Position Dilution of Precision (PDOP)
A unitless figure of merit expressing the relationship between the error in user position and the error in satellite position. Geometrically, POP is proportional to 1 divided by the volume of the pyramid formed by lines running from the receiver to four satellites observed. Values considered 'good' for positioning are small, say 3. Values greater than 7 are considered poor. Thus, small PDOP is associated with widely separated satellites. PDOP is related to horizontal and vertical DOP by $PDOP^2 = HDOP^2 + VDOP^2$. Small PDOP is important in positioning, but much less so in surveying.

Photogrammetry
An aerial remote sensing technique whose latest innovations employ a high-resolution aerial camera with forward motion

compensation and uses GPS technology for pilot guidance over the designated photo block(s). Photogrammetry forms the baseline of many Geographic Information Systems (GIS) and Land Information System (LIS) studies .

Point positioning
A geographic position produced from one receiver in a stand-alone mode. At best, position accuracy obtained from a stand-alone receiver is 15-25 meters, depending on the geometry of the satellites.

POS
Position

Post-processing
The reduction and processing of GPS data after the data was collected in the field. Post-processing is usually accomplished on a computer in an office environment where appropriate software is employed to achieve optimum position solutions.

Precise Positioning System (PPS)
The more accurate GPS capability that is restricted to authorized, typically military, users.

Pseudo-kinematic surveying
A variation of the kinematic method where roughly five-minute site occupations are repeated at a minimum of once each hour.

Pseudorandom noise (PRN)
The P(Y) and C/A codes are pseudo-random noise sequences which modulate the navigation signals. The modulation appears to be random noise but is, in fact, predictable hence the term "pseudo" random. Use of this technique allows the use of a single frequency by all GPS satellites and also permits the satellites to broadcast a low power signal.

Pseudorange
The measured distance between the GPS receiver antenna and the GPS satellite. The pseudorange is approximately the geometric range biased by the offset of the receiver clock from the satellite clock. The receiver actually measures a time difference which is related to distance (range) by the speed of propagation.

PZ-90
The proper designators for the GLONASS reference system. Sometimes referred to as E-90 or PE-90.

RAM
Random-Access Memory. A memory device whose data can be accessed at random, as approved to sequential access. RAM data is lost when power is removal.

Range rate
The rate of change of range between the satellite and receiver. The range to a satellite changes due to satellite and observer motions. Range rate is determined by measuring the doppler shift of the satellite beacon carrier.

RDOP
Relative Dilution of Precision. See Dilution of Precision.

Reconstructed carrier phase
1. The difference between the phase of the incoming Doppler-shifted GPS carrier and the phase of a nominally constant reference frequency generated in the receiver. For static positioning, the reconstructed carrier phase is sampled at epochs determined by a clock in the receiver. The reconstructed carrier phase changes according to the continuously integrated Doppler shift of the incoming signal biased by the integral of the frequency offset between the satellite and receiver reference

oscillators.
- or -
2. The reconstructed carrier phase can be related to the satellite-to-receiver range, once the initial range (or phase ambiguity) has been determined. A change in the satellite-to-receiver range of one wavelength of the GPS carrier (19 cm for L1) will result in a one-cycle change in the phase of the reconstructed carrier.

Real-time
Refers to immediate, GPS data collection, processing and position determination (usually) within a receiver's firmware after the fact with a computer in an office environment.

Real-time kinematic (RTK)
A DGPS process where carrier-phase corrections are transmitted in real-time from a reference receiver at a known location to one or more remote rover receiver(s).

Real-Time Z
Ashtech's proprietary technique that includes Carrier Phase Differential (CPD) processing. Real-Time Z features "on-the-fly" (OTF) ranging data acquisition and differential processing.

Reference Network
A series of monuments or reference points with accurately measured vectors/distances that is used as a reference basis for cadastral and other types of survey.

Reference station
A point (site) where crustal stability, or tidal current constants, have been determined through accurate observations, and which is then used as a standard for the comparison of simultaneous observations at one or more subordinate stations. Certain of these are known as Continuous Operating Reference Stations (CORS), and transmit reference data on a 24-hour basis.

Relative positioning
The process of determining the relative difference in position between two points with greater precision than that to which the position of a single point can be determined. Here, a receiver (antenna) is placed over each point and measurements are made by observing the same satellite at the same time. This technique allows cancellation (during computations) of all errors which are common to both observers, such as satellite clock errors, propagation delays, etc. See also Translocation and Differential Navigation.

RF
Radio Frequency

RFI
Radio Frequency Interference

RINEX
The Receiver-INdependent EXchange format for GPS data, which includes provisions for pseudorange, carrier-phase, and Doppler observations.

RMS
Root Mean Square. A statistical measure of the scatter of computed positions about a "best fit" position solution. RMS can be applied to any random variable.

RTCM
Radio Technical Commission for Maritime Services
P.O. Box 19087
Washington, DC. 20036-9087

RTCM SC-104 Format
A standard format used in the transmission of differential corrections.

SE
Site Editor or Standard Error

Selective Availability (SA)
The process whereby DOD dithers the satellite clock and/or broadcasts erroneous orbital ephemeris data to create a pseudorange error

Spherical Error Probable (SEP)
A statistical measure of precision defined as the 50th percentile value of the three-dimensional position error statistics. Thus, half of the results are within a 3D SEP value.

Sidereal day
Time between two successive upper transits of the vernal equinox.

Sidereal time
The hour angle of the vernal equinox. Taking the mean equinox as the reference yields true or apparent Sidereal Time. Neither Solar nor Sidereal Time are constant, since angular velocity varies due to fluctuations caused by the Earth's polar moment of inertia as exerted through tidal deformation and other mass transports.

Single difference
The arithmetic differencing of carrier phases simultaneously measured by a pair of receivers tracking the same satellite (between receivers and satellite), or by a single receiver tracking two satellites (between-satellite and receivers); the former essentially deletes all satellite clock errors, while the latter essentially deletes all receiver errors.

Spherical Error Probable (SEP)
A navigational measure of accuracy equaling the radius of a sphere, centered on the true location, inside which 50% of the computed solutions lie.

Spoofing
The process of replicating the GPS code in such a way that the user computes incorrect position solutions.

Standard Positioning Service (SPS)
Uses the C/A code to provide a minimum level of dynamic- or static-positioning capability. The accuracy of this service is set at a level consistent with national security.

Standard Positioning System
The less accurate GPS capability which is available to all.

Static observations
A GPS survey technique requiring roughly one hour of observation, with two or more receivers observing simultaneously, and results in high accuracies and vector measurements.

Static positioning
Positioning applications in which the positions of static or near static points are determined.

SV
Satellite Vehicle, Satellite Visibility or Space Vehicle.

Switching channel
A receiver channel which is sequenced through a number of satellite signals (each from a specific satellite and at a specific frequency) at a rate which is slower than, and asynchronous with, the message data rate.

TDOP
Time Dilution of Precision. See Dilution of Precision.

TOW
Time of week, in seconds, from midnight Sunday UTC.

Translocation
A version of relative positioning which makes use of a known position, such as a USGS

survey mark, to aid in the accurate positioning of a desired point. Here, the position of the mark, determined using GPS, is compared with the accepted value. The three-dimensional differences are then used in the calculations for the second point.

Triple difference
The arithmetic difference of sequential, double-differenced carrier-phase observations that are free of integer ambiguities, and therefore useful for determining initial, approximate coordinates of a site in relative GPS positioning, and for detecting cycle slips in carrier-phase data.

Tropospheric correction.
The correction applied to the measurement to account for tropospheric delay. This value is obtained from the modified Hopfield model.

True anomaly
The angular distance, measured in the orbital plane from the earth's center (occupied focus) from the perigee to the current location of the satellite (orbital body).

Universal Time Coordinated (UTC)
Time as maintained by the U.S. Naval Observatory. Because of variations in the Earth's rotation, UTC is sometimes adjusted by an integer second. The accumulation of these adjustments compared to GPS time, which runs continuously, has resulted in an 11 second offset between GPS time and UTC at the start of 1996. After accounting for leap seconds and using adjustments contained in the navigation message, GPS time can be related to UTC within 20 nanoseconds or better.

User Range Accuracy (URA)
The contribution to the range-measurement error from an individual error source (apparent clock and ephemeris prediction accuracies), converted into range units, assuming that the error source is uncorrelated with all other error sources. Values less than 10 are preferred.

UT
Universal Time

UTM
Universal Transverse Mercator Map Projection. A special case of the Transverse Mercator projection. Abbreviated as the UTM Grid, it consists of 60 north-south zones, each 6 degrees wide in longitude.

VDC
Volts Direct Current

VDOP
Vertical Dilution of Precision. See Dilution of Precision and Position Dilution of Precision.

WGS
World Geodetic System

World Geodetic System 1984 (WGS-84)
A set of U.S. Defense Mapping Agency parameters for determining global geometric and physical geodetic relationships. Parameters include a geocentric reference ellipsoid; a coordinate system; and a gravity field model. GPS satellite orbital information in the navigation message is referenced to WGS-84.

World Geodetic System (1972)
The mathematical reference ellipsoid previously used by GPS, having a semimajor axis of 6378.135 km and a flattening of 1/298.26.

WP
Waypoint

Y-Code
The designation for the end result of P-Code during Anti-Spoofing (AS) activation by DoD.

Y-code tracking, civilian
Signal squaring (now obsolete) multiplies the signal by itself, thus deleting the carrier's code information and making distance measurement (ranging) impossible. Carrier phase measurements can still be accomplished, although doubling the carrier frequency halves the wavelength.

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